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Portable Electric Plants.

The increasing use of electrical equipment in various construction work brings to mind the somewhat undeveloped state of portable plants for such service. Of course it often happens that work is being carried on within easy reach of central-station service, and in such cases it is a simple matter to make suitable arrangements for it. Yet it is common enough to find construction in which electric hoists, cranes and drills would be extremely useful, to say nothing of electric lighting, in localities where no available plants are within reach. If the works are of sufficient size it may be feasible to install a regular temporary plant as was done in the Kern River tunneling operations of the Los Angeles Edison Co. In this case a regular hydraulic transmission plant was put in and very successfully used throughout the period of construction. It is rare, however, to find need for power generation on so large a scale. In most instances a really portable equipment is needed, one that can easily be taken from place to place ready to operate motors and other apparatus whenever needed. Some few portable plants designed for various purposes are in existence, but it seems obvious that a great deal more can be done in this line, especially since the automobile has made small gasoline equipments so familiar that they are taken quite as a matter of course.

It is certainly no difficult matter to plan a combined auto truck and portable power station of say 40 or 50 electrical horse-power capacity, using a four-cylinder gasoline engine direct-connected to its generator and quite capable of furnishing power and lights on a considerable scale. The load conditions are not, of course, good, but they are certainly more favorable than in the case of the scattered steam engines now used. The gain in economy and facility is of no small moment, and there are many electrically-driven tools available for which there are no steam-driven equivalents. So far as economy of operation is concerned, there is certainly advantage in using gasoline engines rather than steam engines in the smaller outputs, while the electric equipment requires a smaller working force. In the matter of lighting for night work, the judicious use of arc lights is probably the best thing yet devised, the flaming arc having been used with particular success in excavations and other places which are exceedingly difficult to light with ordinary lamps or torches.

The small portable power plant certainly has a useful field, and were apparatus more readily available, it would be oftener tried. Very possibly some of the readers of The Engineering Record may have had experience with portable plants of one sort or another, and they would do their fellow engineers a good turn by giving them the benefit of the experience. In these days of difficult labor conditions, the more the better of auxiliary power apparatus. It has already demonstrated its usefulness, and the only trouble is that its field is as yet too contracted.

Compression Members for Bridges.

The built-up compression members used so universally in American bridge practice, commonly of laced channels or channels laced on one side and riveted to a cover plate on the other, the channels being either rolled or built, are members of such every-day construction that the usual procedures involved in their design have long since come to be accepted without any question whatever. The fundamental principles of long-column resistance as established many years ago, are fully recognized, the moments of inertia of cross-sections being computed in all cases as if there could be no possible question of all component parts of the column being held rigidly in their proper relative positions under all degrees of loading up to that causing failure. There is always an implicit, if not explicit assumption that the lacing, rivets, batten plates and other details are provided with sufficient dimensions and in numbers requisite to insure no distortion of the normal cross-section under any loading to which the column may be subjected. These assumptions obviously involve conditions imperative for a proper resisting capacity of the member. No matter what may be the cross-sections of the various parts of which the column is composed, if those parts are not held in their proper relative positions by sufficiently strong lacing or other spacing details and with a sufficient number of rivets of suitable size, it is clear that the column may fail to carry even a small fraction of the load for which it is designed.

Ever since the beginning of bridge construction in this country there have been many experimental investigations made for the purpose of securing complete information regarding the effects of shop processes on structural material in course of fabrication. These experiences have yielded data of so great value that there is afforded fairly complete knowledge of the effects of such manipulations as punching, shearing, cold straightening and other similar operations employed in the manufacture of built compression members. So full, indeed, has this information become that engineers have strangely failed to consider the necessity of testing full-size members of this class as completed and ready to perform their functions in the finished structure.

Forged eye-bars have been the subjects of ceaseless investigation as full-size members, until it would seem as if there could be little left to ascertain regarding their action under any conditions of loading. Suitable dimensions of heads, the proper shape of the neck, the relation between width and thickness, the thickness of head or rather thinness inducing failure by dishing, the conditions for proper forging and other elements of the eye-bar problem almost without number, have been so amply treated as to leave little still to be desired. Indeed it is not too much to say that the eye-bar has come to be probably the most completely determined member used in a modern bridge. The pursuit of experimental knowledge regarding the properties of eye-bars has apparently been so absorbing that corresponding information regarding built-up compression members, although not less important, has been almost completely neglected. During the last quarter century scarcely ten full-size built-up compression members have been tested to destruction and not one large member of that class has ever been so tested. When it is remembered that members of the largest eye-bars yet forged have been subjected to the most careful experimental scrutiny for all degrees of loading up to failure, it must be admitted that the contrast is sufficiently remarkable to cause the gravest apprehensions in the minds of engineers having great compression members to design. This observation gathers much additional force from the fact that the number of full-size built steel columns tested to the present time is so insignificantly small that there would practically be no error in stating that there have been no such tests. All the full-size column tests made in the United States arsenal at Watertown, Mass., and reported in the executive documents of the 47th, 48th and 49th Congresses were of wrought iron, and they afford nearly all the experimental data available for the use of engineers in the design of built-up compression members.

Probably the most important single feature of the ordinary long column is the lacing bars or other similar spacing details. The maintenance of the proper relative positions of the component parts of such columns on which the carrying capacity wholly rests depends absolutely upon the lacing bars, and yet no comprehensive experimental investigation has yet been made to determine their proper sizes and distribution. The maximum panel distance of the lacing in terms of the thickness of angle leg or channel

flange to which the lacing may be riveted is approximately known as is the maximum unsupported width of a web plate for these built compression members, but the dimensions of the lacing bars on which the safety of the entire structure really depends has not even been approximately determined by experimental investigation. The design of those bars is, therefore, almost wholly a matter of the engineer's judgment.

As startling as this condition is regarding the designs of such an important part of built-up compression members, many experienced engineers know that the full-size column tests already alluded to yield some valuable information regarding the design of lacing bars, although it is of an inferential rather than of a positive character. Furthermore those tests have furnished bases for tables of standard lacings for built compression members composed of rolled or built channels from six inches up to thirty-four inches in depth. Although such lists have never been subjected to a series of crucial tests by the actual loading of large columns to failure they certainly accord with the older tests of columns on which they are based.

There has been a tendency at times to economize too much in these details of large structures. This is a mistake as the total metal required for such purposes is always a small percentage of the total metal in the structure, and it requires but a comparatively small amount of metal, properly disposed in such details, to make all the difference between safety and fatal danger. The component parts of great compression members, especially when there are three or four heavy webs, can be held in their normal relative positions only by correspondingly heavy lacing bars or plates, as can be at least approximately concluded from the proportionate bars employed in the latticed channel columns of wrought iron tested at Watertown.

While it is probable that great steel compression members may be safely designed by inference from those early tests, there is still the danger resulting from a legitimate but wide difference of engineering judgment, when acting by such a remote inference. An extended series of tests of full-size steel built compression members is imperatively needed to determine many important open questions on which depend the safety of the structures in which they act, as has been forcibly evidenced by at least one great bridge wreck.

Railway Maintenance and Chemical Research.

Among the problems which are constantly facing the modern railway manager the question of maintenance easily stands in the front rank of importance. Enormous sums of money are expended yearly on every large system to make good the effects of wear and tear, and the increasing traffic and higher speeds of train operation on railways are subjecting the engineering materials and equipment used in transportation to service tests that demand the best quality of supplies for economical performance. Both steam and electric railways are such heavy consumers of timber, fuel, lubricants, iron, steel and other great staple products that the purchasing agent's office is thronged from morning until night with sales engineers and representatives of supply houses; and the stream of correspondence, orders, requests for bids, and the like, never stops flowing. Important as are improvements in the design of locomotives, rolling stock, power plants and general machinery, it is becoming clear that there is a broad field for the saving of money in the purchase and use of supplies. But the physical and chemical characteristics of the materials must be thoroughly understood before intelligent selection and wise application of supplies can be made in bulk.

The co-operation of engineering and purchasing departments has become the regular thing in progressive organizations, and in so far as the physical properties of materials are concerned, operating companies are thoroughly alive to the importance of drawing specifications on the basis of engineering tests. It is only very recently, however, that the relation of chemical research to the engineering field, and particularly to railway maintenance, has begun to be appreciated. The chemical side of power plant work has been referred to in these columns, and the chemistry of the boiler-room is receiving widespread attention. A less general appreciation exists of the ability of the chemist to solve some of the problems of maintenance in busy railway systems, or at least to co-operate in their solution with the experts of the operating staff.

The purchase of steel rails, is, of course, an exception as far as the time element is concerned. It is nothing new to draw rail specifications on the basis of microscopic, physical and chemical tests. Information of this character is absolutely essential to the securing of durability and reliable service. Few engineers outside the sphere of laboratory influence, however, realize the scope of work or the specialization in progress which have lately fallen to the lot of the consulting chemist. It is not too much to say that the single question of fuels has become a special branch deep enough to provide the expert chemical engineer with a life work, and similarly the preservation of timber and the study of lubricants are now subjects of sufficient breadth to occupy the entire attention of specially qualified men. The organization of chemical specialists is a natural outgrowth of this progress, and its power to reduce the total cost of a given material in its life and service in heavy railway work is being demonstrated daily in the cases of companies which have decided to supplement the advice of the engineer with the recommendations of the chemist in holding up the hands of the purchasing agent to enable the latter to buy at the maximum point of advantage as markets rise and fall.

No maintenance problems can be properly solved unless the materials involved are thoroughly understood. In the case of electric railway trolley wheels, for example, an analysis of wheels showing both long and short lines is a necessary condition to the finding of the wheel which shall in the long run be the cheapest, allowing for the differences in cost, mileage and scrap value. Similarly the study of trolley wire composition, the constituents of bearing metals, suspension cars, crossing frogs, ties, insulating compounds, oils, greases and other materials and supplies must supplement the tests of tensile or compressive strength, viscosity, flash and fire points, specific gravity, porosity and other physical properties which enable accurate specifications to be drawn in the interest of reduced maintenance through increased durability.

It is needless to emphasize the importance of chemical analysis and calorimeter tests of fuel in these days when British thermal units, and percentages of carbon, sulphur and ash count for so much with intelligent consumers. At the same time, it is not so generally appreciated that the quality of fuel burned in a given locomotive furnace or under the boilers of a power plant has a direct bearing upon the depreciation of grates and tubes, which demands the report of the chemist before complete data are at hand to judge the fitness of a given fuel for given conditions. Again, it is one thing to specify coal of a certain character and another to make sure that it is delivered and stored in the most acceptable way.

The cost of lubrication is a subject of great importance in railroad circles, and some of the best engineering chemical work has been done with a view toward determining the quality of lubricants best adapted to a given service. The preservation of ties, poles, trestles, and other timber structures is another point of contact between chemical research and railway maintenance, and although the Government has done and is doing a vast amount of work in the field there is room for the commercial chemist to enter more extensively than he has yet done in the general effort to forestall decay and renewal expenses. The study of paints and varnishes is still another question of far-reaching consequence jointly to the laboratory and the operating company, and the attention it is receiving from the Association for Testing Materials is an indication of the general appreciation of its importance. In the scientific purchasing of the immediate future the specifications distributed to competing supply houses will bear the impress of expert chemical knowledge no less than physical, especially in work on a large scale which involves the durability factor.

The Diversion of Underground Waters.

The ownership of underground waters and the right of property owners to divert such waters from their lands have long been the subject of legal controversy. The first important English case of this sort was decided in 1840 and since then there have been a number of decisions which have pretty definitely settled the law regarding underground waters in Great Britain. An excellent account of them was given some years ago in a paper by Lord Robert Cecil, of which a comprehensive abstract was printed in The Engineering Record of Dec. 2, 1899. It was there pointed out that according to the British law there is no property in underground water, but on the other hand, each landowner may pump from his land what water he can get, with two exceptions, viz., he must not directly or indirectly take water already contained in a surface stream, nor must he abstract water flowing underground in a known and definite channel. He has a perfect right to drain the supplies to all his neighbors' well, however long they may have been enjoyed by their owners. So, too, he may pump until springs miles away have ceased to flow. Further than this he may not go. Once water is in the channel of a stream above or underground, it is safe from underground depredation. Many criticisms have lately been made regarding this British law. What was entirely equitable fifty years ago, when underground supplies were of little account, may no longer hold true. Formerly, where a question arose between the draining of a well and the shutting down of a mine, public policy required that the owner of the well should suffer. As the population of cities has grown it has become more and more necessary, where the water is drawn from wells, to drain large tracts of the underground water they contain. The inhabitants of these districts are loud in their complaints of the damage due to their property on this account, while those who are engaged in conveying water to large centers of population claim that the few people in the country must be sacrificed for the many in the towns.

Attention has been called by The Engineering Record a number of times in recent years to decisions of this subject in the United States. Such a controversy arose in connection with the ground-water supplies of the Borough of Brooklyn and attracted much attention. It has also arisen a number of times in other States, and it is a matter of congratulation that in most of these cases the courts have recognized that the

decision should be based, not on the precedents established by a British common law, but on the equities of the case. The climate and geological conditions in different parts of the United States vary, generally being different from those of Great Britain, and a recognition of this fact leads to the inevitable conclusion that what may be justice in one climate and under certain local conditions may be injustice in another. The Minnesota Supreme Court states this very clearly as follows: "Nothing is better settled than that the fundamental principles of right and justice on which the common law is founded and which its administration is intended to promote, require that a different rule should be adopted whenever it is found that, owing to the physical features and character of a State, and the peculiarities of its climate, soil, products and water supply, the application of a common-law rule tends constantly to cause injustice and wrong rather than the administration of justice and right."

This satement was made in a decision in the case of Erickson v. Crookston Water Works, Power & Light Co., 111 N. W. Rep. 391. The company bought two artesian wells in the Crookston artesian basin, well known among those interested in underground water supplies on account of its special features, and by deepening the wells and pumping from these the company obtained a large supply of water which it mixed with an inferior river supply and sold for domestic and other purposes. This heavy pumping from two wells lowered the water level in the ground to such an extent that wells in the vicinity were rendered practically useless, and the suit was brought to prevent it. It was natural to expect an interesting decision in this case, because in the matter of surface water the Minnesota Supreme Court had previously taken a view which was novel at the time it was announced. In the case of Sheehan v. Flynn, the liability of the landowner for diverting surface water to the injury of another was made to depend upon the necessity and reasonableness of the act. Although this rule is subject to considerable criticism even at the present day, it has been followed to a greater or less extent in many Western States. It is natural, therefore, to expect that the decision in the present case involving underground supplies would be similar in its reasoning, following the precedent originally established by the New Hampshire Supreme Court, which was particularly referred to in Lord Robert Cecil's address. In fact, the highest court in the State of New York has made a decision of somewhat like tenor in some of the cases growing out of the use of ground water for supplying the people of Brooklyn.

In Forbell v. New York, 58 N. E. Rep. 644, the court stated: "In the absence of contract or enactment, whatever it is reasonable for the owner to do with his sub-surface water, regard being had to the definite rights of others, he may do. He may make the most of it that he reasonably can. It is not unreasonable, so far as it is now apparent to us, that he should dig wells and take therefrom all the water that he needs in order to the fullest enjoyment and usefulness of his land as land, either for the purpose of pleasure, abode, productivness of soil, trade, manufacture, or for whatever else the land as land may serve. He may consume it, but must not discharge it to the injury of others. But to fit it up with pumps and wells of such pervasive and potential reach that from their base the defendant can tap the water stored in the plaintiff's land and in all the region thereabouts, and lead it to his own land, and by merchandising it prevent its return, is, however reasonable it may appear to the defendant and its customers, unreasonable as to the plaintiff and the others whose lands are thus clandestinely sapped and their value impaired."

Another case which deserves attention on account of the clear reasoning to be found in the decision as well as because of the precedent it establishes in a State where underground waters are specially valuable is that of Katz v. Walkinshaw, 74 Pac. Rep. 766. In this case the underground waters were found below an impervious stratum, the water-bearing material being fed from the rainfall on the slopes of the mountains encircling the valley. When the impervious stratum was perforated, true artesian wells were formed. The court held in this case that such percolating water rising through an artesian well was not a water course, so as to confer riparian rights upon the owners of the surface. It was further decided that the owner of a portion of a tract of land underlaid by such a water-bearing stratum cannot remove the water from wells for sale, if the remainder of the tract is thereby deprived of water necessary for its profitable enjoyment. A somewhat similar decision has been rendered in Texas.

The Minnesota Supreme Court has agreed with these views. It has decided that a water company had no vested right to deprive the neighboring land owners of water, naturally furnished by artesian wells, by pumping the water from its own wells to such an extent as to lower the whole underground water level. It will be seen that this is diametrically the opposite view to that of the British common law. It is in harmony, however, with a minority opinion by Lord Wesleydale in the famous case of Chasemore v. Richards, decided in 1857. Lord Wesleydale stated that a land-owner ought to exercise his right in a reasonable manner, with as little injury to his neighbor's rights as may be. He doubted the legality of a water purveyor's act in abstracting water for the use of a large district in the neighborhood unconnected with his own estate, for the use of those who had no right to take it directly themselves and to the injury of those neighboring proprietors who had an equal right with themselves. Each person who was supplied with water by the purveyor might not have been able to dig a well on his own land and take the like quantity of water, so that the purveyor may have taken much more than would have been abstracted if each had exercised his own right. These opinions of Lord Wesleydale have not been unheld in Great Britain because of the belief of the court that it would be impracticable to determine what was a reasonable use of underground waters. It will be seen that the American courts have been deterred by no such fear, and that in many of our States, as mentioned above, what is legal in respect to underground waters is made to depend solely upon what is reasonable.

Notes and Comment.

Economy of Manufacture in cement mills is brought to the front in Mr. Potter's interesting paper on the use of electricity in such plants printed in The Engineering Record, Sept. 21. The change taking place in such works at the present time as a result of the introduction of electricity and various other improvements is particularly noticeable. Attention is being paid everywhere to methods of reducing the cost of manufacture without deterioration in the quality of the product. That there is plenty of opportunity for improvement is generally admitted by cement manufacturers. The industry suffered in one sense from the fact that its product is mainly consumed during the months when work can be carried on readily out of doors. As a result of this fluctuation in demand, there is an accumulation of stocks every winter, so that when spring arrives it is natural for the manufacturer to feel very apprehensive concerning the future, for he generally has a large amount of capital locked up in unsold product. The manufacturing problem, then, is to meet economically a demand which is not unlike that thrown on central electric stations. There is a peak load which must be provided for by special means, an average load from which profits must be derived and a minimum load which must be brought up as high as possible in order to keep down manufacturing cost. Of course electricity will not be of much use in equalizing supply and demand, although it is certain that it will be a help in reducing operating expenses. There has been a tendency among some of the older companies to look upon electricity as too unreliable for a mill operating with such clouds of abrasive dust as arise in cement work. It is only necessary to refer to the many plants where electricity has been in satisfactory service for years to show that these fears are unfounded. One result of the adoption of electrical machinery, has been, however, the demonstration of the uncertainty new existing regarding the actual demand for power in cement production. Mr. Potter's statement concerning the good results which will inevitably follow careful investigation of this feature of cement works deserves consideration. Until it is known just how much power is required to operate the heavy machinery with different kinds of materials, it is out of the question to design the most economical electrical drives.

An Evidence of Civic Pride that deserves more than passing attention has recently been received from Frankfort-on-the-Main. The public works of this city have long been noted among engineers. The sewerage and water systems have been places of pilgrimage for twenty years, and the harbor works are among the most interesting in Germany. The city has been growing quite rapidly, and instead of allowing it to develop without restraint, a great deal of thought has been paid to the laying-out of all the suburbs. The pavement and methods of street cleaning are in keeping with the other public works, and taken all in all, there is probably no city in Germany which better repays examination by those interested in municipal works. This is so well known that a host of visitors connected with such affairs elsewhere go to Frankfort annually on inspection tours. These visitors have always been welcomed warmly and all possible information placed at their disposal. Nevertheless, the burden of supplying data to so many callers has been a somewhat serious matter and accordingly the city engineering department has prepared an excellent guide to all the public works under its charge. This has been published in an attractive form, editions being available in English, French and German. Such a book not only saves the members of the engineering staff of the city a considerable amount of time in answering the general inquiries of visitors, but it also insures to the latter absolutely accurate information free from defects that might creep in when general statistics are compiled hastily. The book is particularly interesting because it is printed by the city for free distribution to all who are interested in the Frankfort undertakings. It indicates a pride in the works built at the expense of the municipality which is rarely shown so clearly. There are a number of cities in this country which have public works of high character. Boston, for instance, contains many undertakings of this sort, and yet even Boston, noted for its municipal self-esteem, has not been so proud of its excellent engineering works that it has been willing to spend a few hundred dollars preparing a guide to them for the many visiting officials of other cities.

THE SEWAGE PURIFICATION PLANT AT READING, PENNSYLVANIA.

The city of Reading, Pa., is at present completing part of an interesting sewage purification plant which is the nucleus of an extensive system to be developed as the needs of the city require. The new installation consists of a sewage screening device, a septic tank, a sprinkling filter and a final settling basin.

The purification of the sewage of Reading was begun about 12 years ago when the present separate sanitary sewerage system was built. The system drained by gravity to a pumping station on the banks of the Schuylkill River in the lower part of the city and was pumped about 6,600 ft. to a filter plant. The treatment of the sewage was begun at the end of the gravity system and before pumping, by being passed through a 12-in. straining layer of fine coke, held in place by iron screens. The filter had two decks, one above the other, each deck having an area about 50x250 ft., the upper deck being supported about 10 ft. above the lower by an iron framework. The filtering material on the decks consisted of layers of graded slag, covered with sand. The sewage was thoroughly aerated by dropping freely through the air some 10 ft. to the lower bed. The results with this combination of a screening device, and double filtration accompanied by aeration are stated to have been quite satisfactory at first, the effluent being clear and of a good sanitary quality, but as the amount of sewage increased owing to new house connections to the sewers and the use of the coke strainers was discontinued, the filter became overtaxed, and required a great deal of attention to relieve clogging of the surface.

In 1905 the city contracted for the construction of about 60 additional miles of sewers, and in consequence the purification problem again became prominent, the more so, too, because the Department of Health of the State of Pennsylvania by an act of the Legislature had been given supervision of the discharge into rivers of the effluents of all sewers built after the passage of the act. Since the city was unable to issue bonds for the construction of the additional purification works, it was decided to call for bids for the construction and operation by a contractor of the necessary plant. The proposed contract was for a 5-year period, the compensation being a fixed sum which was to cover both the operation and the construction of the additional purification plant and the operation of the present pumping station. Mr. O. M. Weand, a Reading contractor, offered the only bid.

Study of the Problem.—Before the contract was closed the city decided to have the sewage problem thoroughly studied in order to determine the most efficient and economical purification system for the local conditions, and accordingly Messrs. Hering & Fuller, of New York, were retained as consulting engineers in March, 1906, acting in coöperation with the city engineer, Mr. Elmer H. Beard. Mr. S. J. Lewis was the assistant engineer in immediate charge. The investigation was begun at once and a small but well-equipped laboratory for making chemical and bacteriological analyses was installed by the city for the prosecution of the work. It included a study of the composition and quantity of the sewage, the performances of the old filter and of the devices suggested by Mr. Weand, when operated separately and in combination, and a comparison of these data with practical experience in purifying similar sewage elsewhere.

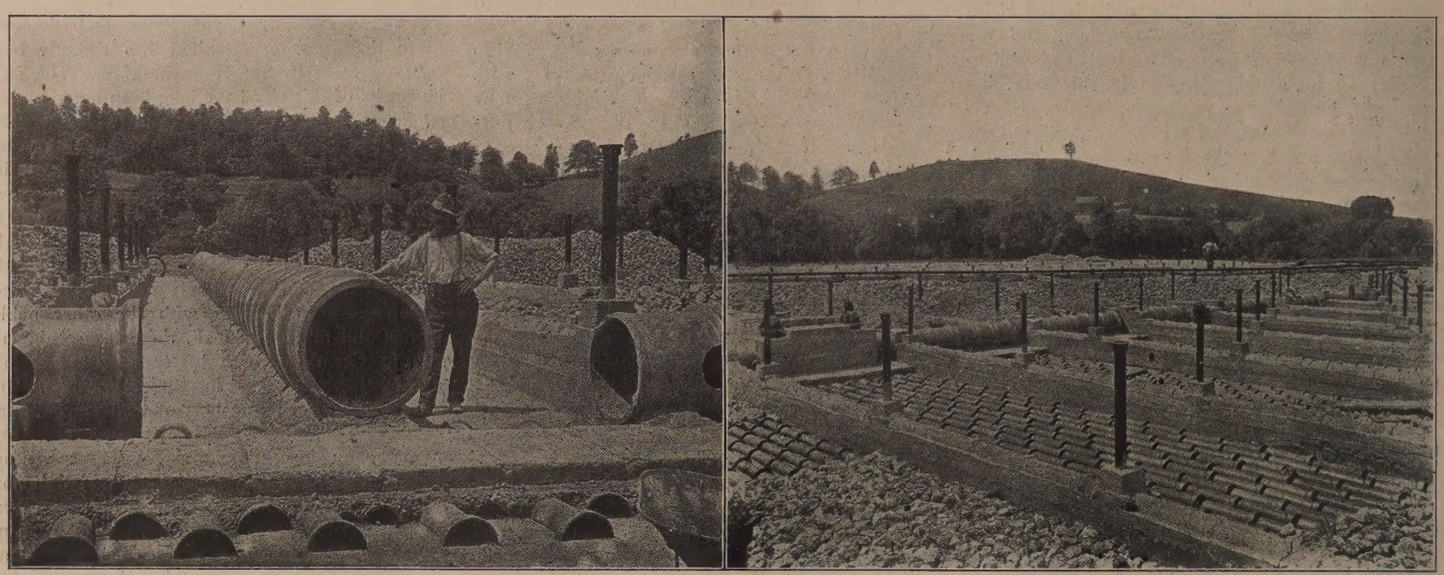
Plan of Filter Beds.

The average volume of sewage was about 2,000,000 gal. per 24 hr., at the time of the report of the city and the consulting engineers in July, 1906, and at times of very wet weather increased to about 2,750,000 gal. The sewage was found to be quite dilute, and was essentially of a domestic nature, though mixed with a limited quantity of trade wastes. A further investigation has also been made of these wastes, and it has been determined which shall receive preliminary treatment before being admitted to the sewers, and which may be admitted without such treatment, those requiring treatment being such as would interfere with the normal operation of the purification devices. The average composition of the sewage in parts per million was found to be as follows: Oxygen consumed 40, chlorine 100, total suspended matter 113, of which 78 parts were volatile and 35 parts fixed. About 40 per cent. of the organic matter was in suspension, and about half a part of nitrogen was found as nitrates. The average bacterial content was 2,200,000 per cubic centimeter.

Results of the Experiments.—In order to study the old filter part of it was restored to its original condition with fresh material. Both the upper and lower beds consisted of a 4-in. layer of 2 to 3-in. slag, 1 in. of ½-in. slag, 2 in. of ⅛ to ¼-in. pebbles, and 12 in. of clean, sharp, washed sand of medium size, the layers being in the order named starting from the bottom upwards. Raw sewage was applied to the upper bed at a rate of 1,000,000 gal. per acre per 24 hr., the rate which the filter was expected to handle when it was designed. Though the sewage was quite dilute, it was found difficult to operate the filter at this high rate. The effluent was non-putrescible and fairly clear, the suspended matter averaging 19 parts per million or 13 per cent. of the content of the applied sewage, the organic matter being reduced 74 per cent., and the nitrates increasing from 0.5 to 3.2 parts per million. The bacterial removal was from 66 to 76 per cent., and the liquid was almost saturated with oxygen both before and after its passage through the lower bed. The sewage was applied intermittently, 4 hr. periods of dosing and resting giving best results.

With this rate it was necessary every two or three days to remove a slimy deposit, ⅛ in. thick, from the surface of the upper bed, amounting to about 41 cu. yd. for each million gallons of untreated sewage that was filtered. The conclusion reached by the engineers was that the cost of maintenance was too great, even though the effluent was good, a conclusion agreeing with the general feeling that the sewage applied to filters should first be freed of the greater part of the suspended matter.

The preparatory devices proposed by the contractor consisted of two moving screens fastened together, one of 80 and the other of 40 meshes to the linear inch. For test purposes such a screen of brass cloth was built, together with a



Sprinkling Filter for Sewage Purification, Showing Distributing System and Drains.

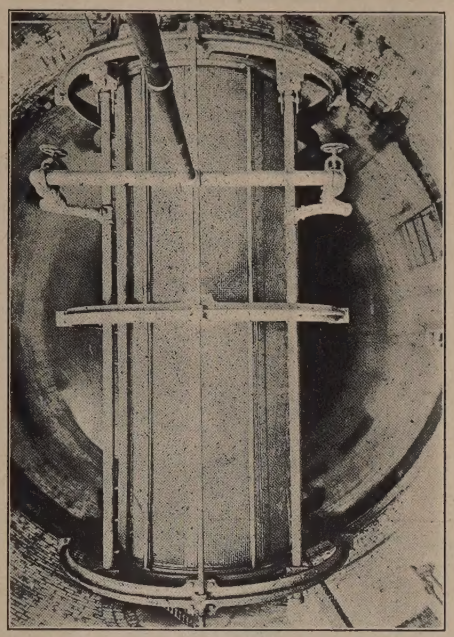
box or flume about 3 ft. deep, 10 ft. wide and 40 ft. long filled with coke. The sewage was passed onto the screen and fell through to the flume, the fine screen retaining quite a quantity of coarser suspended matter, a portion of which was discharged at one end of the screen. The suspended matter remaining on the screen was removed by steam jets. The volume of wet sludge, containing 73 per cent. of water, averaged about ⅓ cu. yd. per million gallons of sewage treated. The rate of application of the sewage to the screen was limited only by the quantity that can be treated by the coke strainer and the filter. The total suspended matter removed by the screen which has been locally termed a "segregator," was 20 per cent., and by the segregator and coke strainer combined 47 per cent.

When the filter was worked with the sewage already treated by the preparatory devices just discussed, the highest rate found advisable was the same as when the filter was treated with raw sewage, 1,000,000 gal. per acre per day, but the clogged material removed from the sand surface averaged but 11 cu. yd. per million gallons treated. The effluent was practically of the same quality as obtained when the filter was treated with raw sewage, the benefit of the preparatory devices being found in the reduction by about 75 per cent. of the clogged sand which must be removed.

Plan Recommended.—The report of the city and the consulting engineers, made to the Board of Public Works, after comparing purification experiences at Reading and elsewhere, finally recommended the following plan. 1. The sewage should first be thoroughly screened, the removal of the fibrous materials in certain of the local trade wastes being a special reason for so doing. 2. The well-screened sewage should be further treated by straining through coke or by sedimentation in a septic tank to remove still more of the suspended matter, the septic tank, in proportion to the work done, being much the cheaper of these means. 3. The aeration of the sewage effected by the double-deck filter is very important, but for economical reasons should be done by means of sprinkling filters, the filtering material being not less than 5 ft. thick and the particles not smaller than ½ in. 4. There should be sedimentation in shallow basins, holding one or two hours' flow in order to remove the scales of deposited material which have dried and peeled off the coarse filtering material.

This system is expected to produce a non-putrescible effluent and remove 90 per cent. or more of the bacteria in the original sewage.

The engineers further recommended that the present filter be dismantled and the framework be used in constructing a septic or settling tank for preparatory treatment, that the upper portion of Fritz's Island lying in the Schuylkill River half a mile below the old plant be purchased by the city as a site for the sprinkling filters, and that a contract be executed with Mr. Weand for the construction and operation of the purification plant.



Top View of Segregator, Looking down into Well.

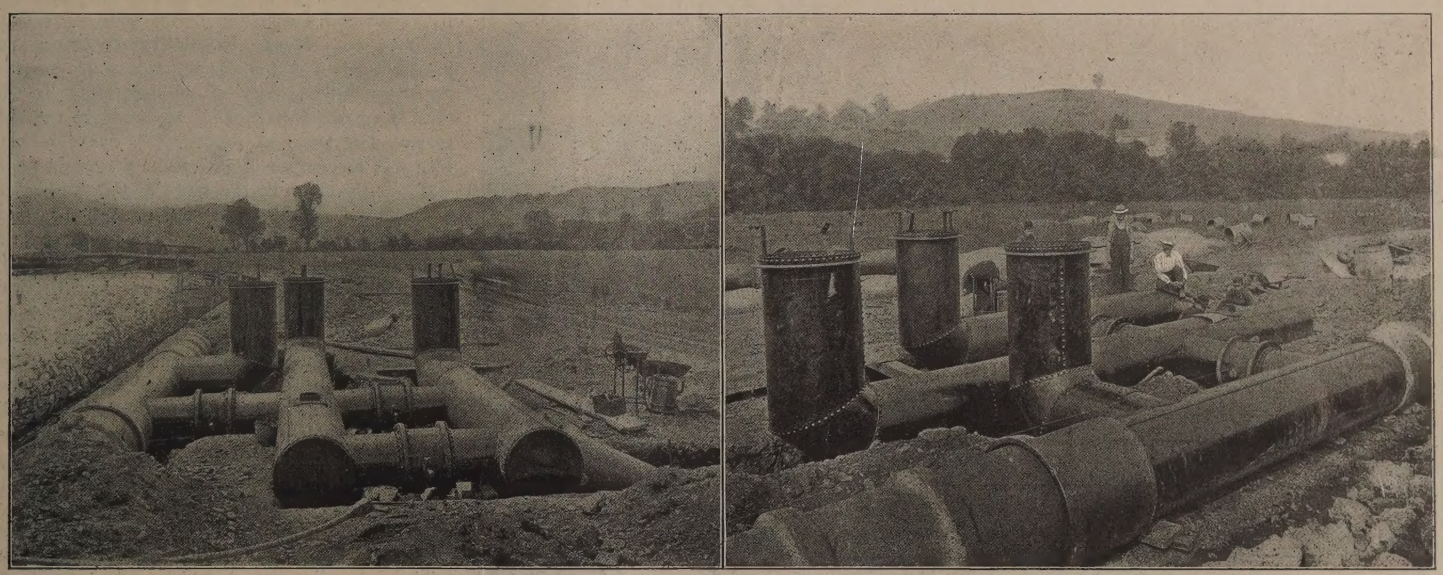
In accordance with these recommendations the contract with Mr. O. M. Weand was executed, which requires him to provide eventually for purifying a maximum of 7,000,000 gal. of sewage per day, to contsruct a second filter bed as soon as the increase in house connections demands it, and to operate the purification works and pumping station for five years. The contractor is to be paid a fixed sum yearly, and at the expiration of the contract the new works constructed and the improvements made revert to the city.

Accordingly the pumping plant in the city and the old filter were turned over to the contractor, and the new works commenced. The quantity of sewage to be treated at present requires the construction of only one bed, with an area of one acre, it being estimated that this will produce a non-putrescible effluent with a maximum rate of 3,500,000 gal. per acre per day, with the present dilute condition of the sewage during wet weather.

Pumping Plant and Screening Device.—The sewage pumping plant, to which the sewers drain by gravity, is located on the bank of the Schuylkill River in the lower part of the city. It has been used continuously since the installation of the original filter plant until the operation of the latter was discontinued on account of the new construction. The building contains an engine room, boiler room, and two wells, 20 ft. in diameter in which the coke strainers of the former purification system were located. In one of these wells the new rotating screening device, called a "segregator" by the contractor, has been installed, the other well being idle and reserved until such time as the quantity of sewage will make it necessary to duplicate the present apparatus.

The segregator, which has been patented by the contractor, consists of a screen 6 ft. in diameter and 16 ft. long, which revolves about a horizontal axis. The screen proper is of brass wire cloth, 40 meshes to the linear inch, which is fastened to a heavier "body" screen of ¾-in. mesh galvanized iron wire by being soldered at intervals of about 6 in. in each direction. The revolving frame consists of three heavy cast iron rings, one at each end and one at the center of the screen, held in position by six 1½-in. extra heavy pipes, through which bolts have been passed and screwed up tight. These rings carry iron strips, running the length of the barrel, which divide the circumference into eight segments, and carry bolts for attaching the removable strips holding the 40-mesh screen in place. The latter is made in these small segments so as to be easily removable to facilitate repairs, while the heavy body screen is in three pieces and attached permanently to the revolving frame. The latter revolves on the three heavy rings, which bear on six 12-in. cast iron wheels, two being attached to each of the three stationary rings, constituting the stationary frame of the segregator, and concentric with the heavy rings of the revolving element. The wheels on each ring are placed a short distance on either side of the lowest point of the screen, and a third 12-in. wheel at the top of each ring serves merely as a guide. The heavy rings of the stationary frame are held in position by three 1½-in. extra heavy pipe, with bolts through them, as described for the revolving frame.

Attached to the outer rings on each side of the top of the screen are hangers carrying two 3-in. pipes, to each of which 15 cleaning jets are at-



Piping and Valves for Automatic Device for Dosing Filter Bed.

tached, for directing water, steam or air against the outside of the screen. The jets are on 10-in. centers, and the two header pipes are made to travel 12 in. laterally, so that the travel of each jet overlaps 1 in. on the travel of each of its two neighbors, assuring the thorough cleaning of every part of the screen. The header pipes are connected to the stationary pipe by flexible pressure hose. The cleaning jets are 3-32 in. in diameter and can be operated under any perssure up to 200 lb. per square inch, though it is expected that 20 lb. will be sufficient to wash the sludge from the inside of the screen. Valves are provided to supply the jets with water, steam or air, or all three or any two of these together. The condenser water will generally be used, the heat helping to remove the sludge on the screen. The segregator makes 3 r.p.m., the power being transmitted by a link belt from a 2½-h.-p. engine.

The sewage enters the revolving screen at one end through a 24-in. main, the center of which is in the axis of the screen. A circular baffle plate 8 in. beyond the end of the pipe breaks the flow and spreads it to the circumference of the screen. The cleaning jets operating under pressure will loosen the sludge, which otherwise would clog the fine mesh, and thus a clean screening surface is always offered to the raw sewage. The sludge, gradually working to the open end of the screen opposite the sewage inlet, will be caught by a bucket conveyor and raised to the floor of the station, where a spiral conveyor will carry it to a hopper, to be discharged into bags. These bags will be placed in a Shaum & Uhinger centrifugal wringer, with a 42-in. basket, making 800 r.p.m., and the liquid forced out of the sludge. The latter will then be sold for fertilizer or mixed with coal for use as fuel, tests showing that it burns well.

The steam plant contains three 60-h.-p. Orr & Sembower boilers, two combined circulating and air pumps for the condenser, and two duplex compound-condensing plunger-pattern Snow pumps of 5,000,000 gal. capacity each.

From the pumping station the sewage, after passing through the segregator, is forced through 6,600 ft. of pipe to the septic tank located on the other side of the Schuylkill River at Millmont. The first 250 ft. is of 36-in. cast iron pipe, the next 450 ft. under the river of 30-in. pipe, and the remainder of 20-in. pipe.

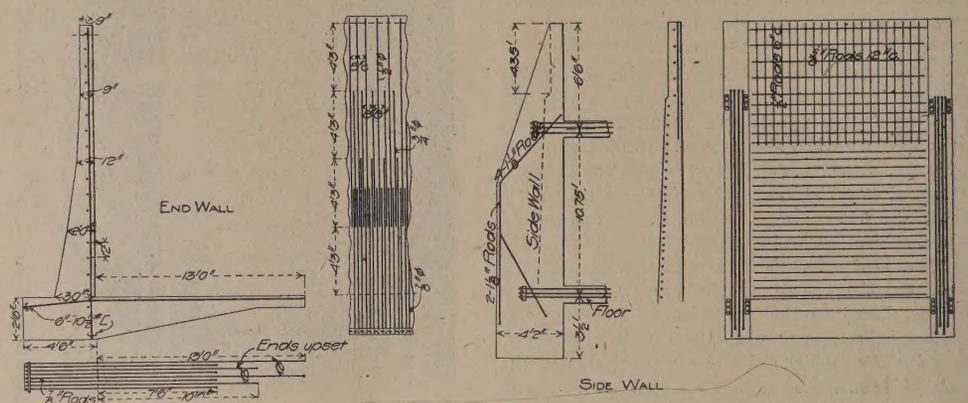
Septic Tank.—The septic tank occupies the site of the former filter and utilizes part of the iron framework of the latter. Its elevation is such that the flow through the succeeding stages is entirely by gravity, even to the final discharge of the purified effluent into the river. The tank is not covered, measures 51 ft. 8 in. by 253 ft. inside and is 17.35 ft. deep. The sewage will normally stand 1 ft. below the top of the wall, and at that stage the tank will have a capacity of about 1,600,000 gal., giving an average period in the septic tank for a 3,000,000 gal. per day flow of about 12¾ hr. and for a 7,000,000 gal. per day flow of about 5½ hr.

The tank is of reinforced concrete, the reinforcing consisting of round rods, and the concrete of a 1:2:4 mixture, using Lehigh Portland cement, and slag, with a maximum size of 1½ in. The sewage enters the tank at one end through a 14-in. riveted steel header about 45½ ft. long, supported by two concrete columns, and the 20-in. vertical pipe, through which the sewage comes through the floor of the tank and enters the header. Twelve 5-in. holes 45 deg. below the horizontal are cut into the header, spaced 3½ ft. on centers. The header is 11 ft. above the floor and about 6 1-3 ft. below the top of the wall.

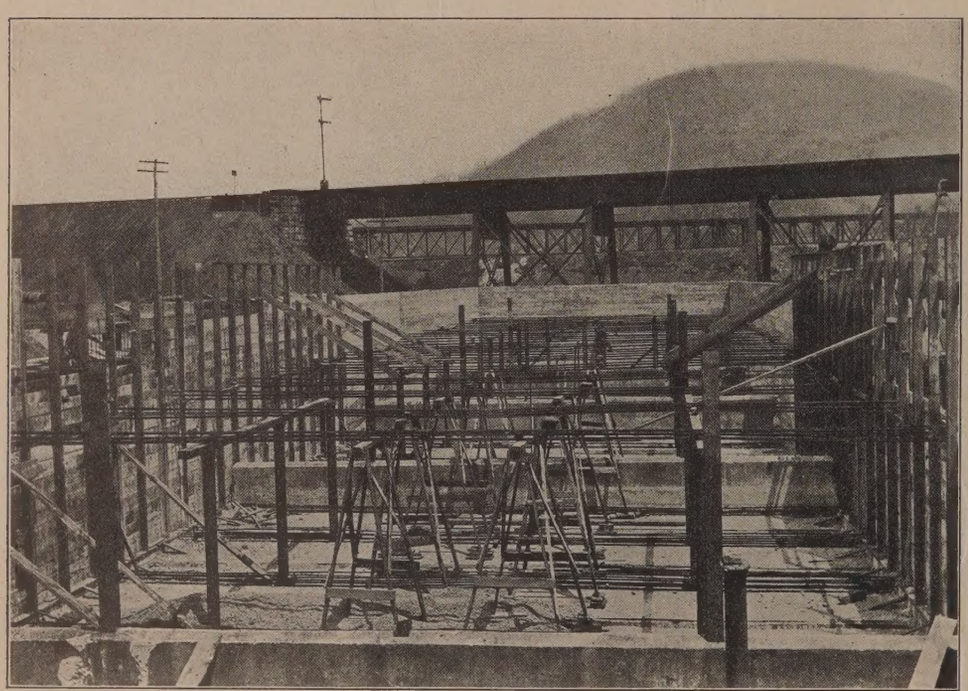
The outflow is over a timber weir and into a trough at the end of the tank opposite the inlet header, the crest of the weir being 1.15 ft. below the top of the wall. The weir and trough run the width of the tank and are supported by timber posts and by the 24-in. vertical effluent pipe, which is bolted to the bottom of the trough. The latter, which is 2 ft. deep, is anchored to the walls by spikes driven into wooden plugs set in the concrete. A 2-in. scum board, with its bottom 1 ft. below the crest of the weir, is mounted 5 in. in front of the latter.

An overflow weir 32 ft. 3 in. long, with its crest 0.7 ft. below the top of the wall, has been built in one of the side walls near the discharge end of the tank, and is fitted with a scum board. An apron projects 10 in. so as to throw the overflow away from the wall. Four baffle walls 4 ft. high, being part of the old filter structure, extend across the width of the tank, dividing it into five equal bays.

The side walls of the tank are 9 in. thick at the top and 18 in. at the bottom and are supported by reinforced buttresses 24 in. wide, spaced 12 ft. 9 in. on centers. In addition to being supported by these buttresses the side walls are tied together in the planes of the buttresses by two sets of round steel tie rods anchored in the buttresses and enclosed in concrete, one set being placed in a concrete "beam" 12 in. deep, and 14 in. wide on the floor of the tank, and the other set in a "beam" of the same section, with its center 10½ ft. above the lower one. The portion of the side walls below the upper "beams" and 1½ ft. above them has horizontal reinforcement, the wall acting as a girder, with the buttresses as supports. The portion above the "beams" has vertical as well as horizontal reinforcement and is figured as a cantilever, the stress being carried to the lower part of the wall rather than to the buttresses directly. Each buttress encloses one of the cast iron columns of the framework of the old filter, and two similar columns and one concrete column support each of the upper "beams" at the quarter points of the width of the tank. The buttresses are 4 ft. 2 in. long from the inside of the walls.



Reinforcement of End and Side Walls of Septic Tank.



Septic Tank under Construction, Showing Tie Rods Exposed.

The end walls are 30 in. thick at the bottom and 9 in. at the top and, not having any tie rods running between them, are supported by vertical reinforcing rods, which carry the stress as a cantilever to a reinforced toe extending 13 ft. inside the tank.

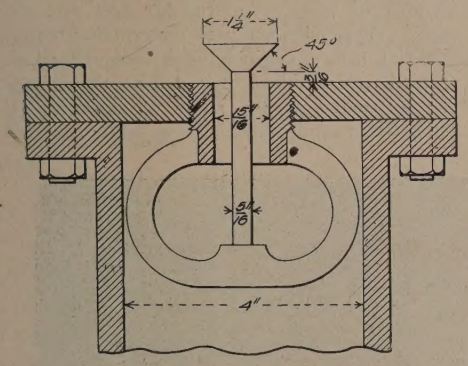
The horizontal steel in the end walls varies from ⅝ to 1 in. in diameter and is placed 12 in. on centers, while the vertical rods are ⅞, ¾ and ½ in. in diameter, spaced 3 in. at the bottom, not all of the rods running to the top of the wall. The rods in the toe are ⅞ in. on 3-in. centers and are anchored at the outer ends to 6-in. 10½-lb. channels.

The horizontal rods in the side walls are ⅞ and 1 in., with spacing varying with the height and diameter of the rods, from 5 to 7 3-16 in. The vertical rods are ½ in. on 6-in centers. In the upper, or cantilever, portion of the side walls are horizontal rods ⅝ in. diameter, spaced 12 in.

There are four 1⅛-in. rods in each buttress. In the lower tie "beam" there are four 1⅛-in. rods, and two ⅞-in. rods, anchored at both ends in the buttresses to 6-in. 10½-lb. channels. In the top "beam" there are four 1-in. rods and two ⅞-in. rods, anchored as in the lower "beam."

The concrete was hand mixed and placed very wet in watertight forms. No water-proofing was applied, to insure water tightness. After the walls had been built, scaffolding was erected inside the tank for mixing the concrete for the "beams," and the materials delivered to it over runways extending along the top of the wall. A by-pass will be built around the tank so that the sewage can be diverted to the filters when the tank is being cleaned.

The effluent from the septic tank will flow under pressure, due to the elevation at which the tank is built, to the filter beds, about 2,500 ft. beyond. The pipe will be laid under an independent contract and will pass under a small creek and the smaller branch of the Schuylkill



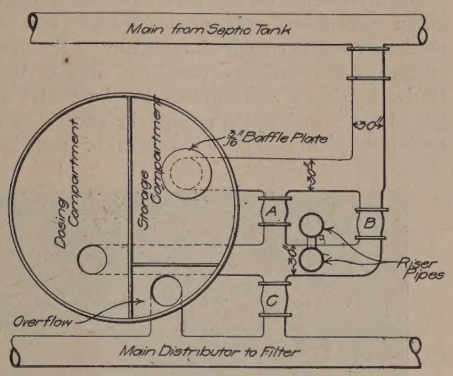
Sprinkling Nozzle for Filter.

River, the filter beds being on an island. The pipe will be 30 in. in diameter, built of concrete.

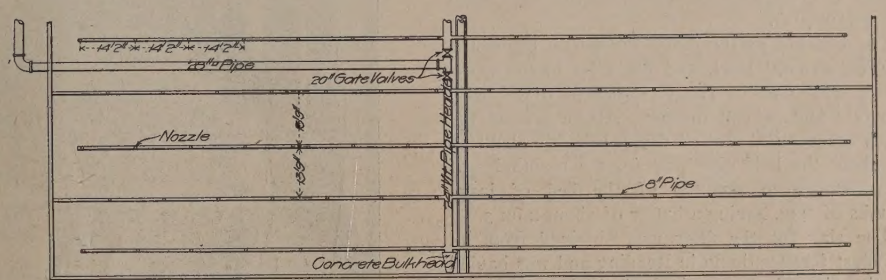
Filter Plant.—The site of the filter plant is a 30-acre tract on Fritz's Island, which slopes downward, looking up the river and to both sides, so that the effluent can readily be discharged into both branches of the stream. The situation is almost ideal for a filter plant, the more so because it lies considerably below the septic tank site. The highest part of the area is 12 ft. below the weir level and 17 ft. above the river at normal low water and slopes gently toward both branches. The filter floor is 8 ft. lower, the excavation on the area covered being from nothing to 5 ft. The ground has been laid out for eight beds of one acre each, four on either side of the 30-in. main from the septic tank. Each bed will have a separate dosing apparatus and a final settling basin, the latter being placed on the lower side, away from the filter influent main, so as to be filled by gravity from the bed. The settling basin in turn will discharge by gravity into the river. At the present time only one bed has been built, and it is so far completed that it can at any time be put in operation in a few hours. The work now waits on the completion of the pipe from the septic tank.

The filters are of the sprinkling type, the nozzles operating under a head varying from 7 to 2 ft., so as to distribute the sewage uniformly over the area served by each nozzle. The circumference of the spray is at its maximum under the highest head and gradually diminishes to about 3 ft. circumference. When the head drops to 2 ft. the flow ceases and the bed rests from 2 to 4 min., after which sprinkling again commences under a head of 7 ft. The filtering material is a 6-ft. bed of blast furnace slag, varying in nominal size from 1½ to 4 in. The bed as it now stands is 5 ft. thick.

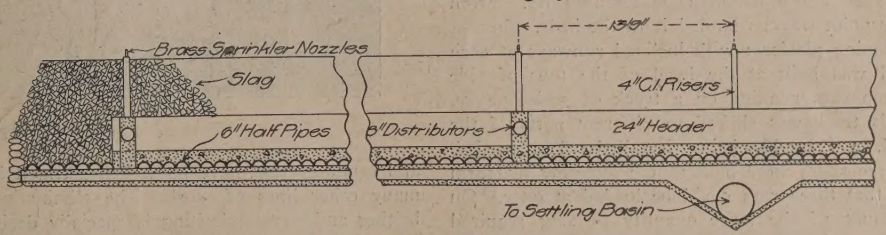
Dosing Apparatus.—The dosing apparatus, which automatically controls the flow of sewage to the nozzles, is located between the main from the septic tank and the filter bed midway of the side of the latter. It consists of an elevated wooden tank 19 ft. in diameter divided by interior walls into three compartments of unequal size, the flow into and out of which is controlled by three butterfly valves operated by floats. The largest compartment is called the dosing compartment, the next in size the storage compartment and the smallest the overflow compartment. A 30-in. riveted steel pipe connects with each compartment through the bottom of the tank. The sewage coming from the main from the septic tank flows through a 30-in. pipe at right angles to the former and then into another 30-in. pipe parallel to the side of the filter bed. This pipe terminates in the storage compartment, which is always open to the flow from the septic tank. Two butterfly valves are placed between the pipe leading to the storage compartment and a parallel one to the dosing compartment. A third butterfly valve is interposed between this latter line and the main distributor to the filter, the latter being



Dosing Apparatus.



Plan of Filter Distributing System.



Section through Filter Bed at Main Drain.

likewise connected to the overflow compartment by a short length of pipe. Cast iron riser pipes, containing the floats which operate the valves, are connected by 8-in. nipples to the 30-in. pipe leading to the dosing tank. All of the piping is of 3-16 in. riveted steel, except the float pipes. The valves are 20 in. in diameter.

The operation of the apparatus is as follows, the valves being described by the letters on the accompanying diagram: Starting at a time when there is no flow from the nozzles, valve A is open and B and C are closed. The sewage is then filling both the dosing and storage compartments, the level being the same in both, since they are connected through valve A. As the water rises valve B gradually opens, and when the compartments are full, equal to a head of 7 ft. on the nozzles, B is wide open, A closes and C opens, allowing the compartments to drain onto the beds and also the sewage to flow through valve B directly from the septic tank. When the head on the nozzles has dropped to 3½ ft. valve B closes, shutting off all connection between the septic tank and the nozzles and allowing the storage compartment to refill. The discharge from the dosing compartment continues until the head on the nozzles is 2 ft., when valve C closes and A is opened, restoring the starting condition. A weir is provided between the dosing and overflow compartments to allow a discharge in case the sewage rises over 7 ft. above the nozzles. The cycle of operations described will take from 7 to 8 min., the interval of rest being from 2 to 4 min. of this period. A patent on the apparatus has been applied for by the contractor, Mr. O. M. Weand.

Filter.—The filter bed is rectangular and covers exactly one acre. The main distributor, consisting of a 30-in. glazed tile pipe, runs 46 ft. each side of the dosing apparatus and connects at one end with a 30-in. glazed tile pipe and at the other with a reinforced concrete pipe 28 in. square, both of which run to the center line of the bed. Here they connect with a 24-in. vitrified tile pipe header, which runs the full length of the bed and has in it four valves, one on each side of the two influent main connections, so that each valve can cut off one-fourth of the bed when it is desired to give it a rest. From this header, every 13.7 ft., the 8-in. vitirified tile lateral distributors are taken off, extending at right angles to the header. The 4-in. cast iron pipe risers which carry the sprinkling nozzles are set vertically in tees at intervals of 14 ft. 2 in. in the laterals, the risers on adjacent laterals being staggered. The tops of the risers are 5 ft. above the axes of the laterals and about 1 ft. above the persent top of the slag.

The main and lateral distributors and the header are built on concrete foundations, which for the 8-in. laterals are carried half way around the pipe on each side. All the joints are made with cement mortar. The laterals are joined to the header by cutting a hole through the latter, inserting the lateral and building around the connection a concrete ring about 4 in. thick, reinforced on each side of the smaller pipe with a ⅜-in. rod passing around the header pipe. About half of the cast iron riser pipes are set in the vitrified tile laterals with cement mortar and the other half with Pottsite, and a pier of concrete is carried up around each joint to a point 10 in. above the top of the lateral. A heavy concrete bulkhead at each end of the header takes up the thrust and relieves the cement joints of strain.

The sprinkling nozzles are of the stationary type, a modification of those adopted for the Columbus purification plant, and consist of an inverted frustum of a cone, carried by a rod passing through and in the center of a 15-16 nozzle orifice. The cone slopes 45 deg., is 1¼ in. in diameter across the top and is carried by a 5-16-in. rod, the junction of the rod and cone being 3-16 in. above the plane of the orifice. The cone,

rod and orifice are of brass and are set in a cast iron plate, which is bolted to the top of the riser with the aid of lugs cast onto the latter. A gasket insures a tight joint. This nozzle was adopted by Mr. Weand after numerous experiments.

The effluent drainage system is built on the floor of the filter, which consists of 4 in. of 1:3:6 slag concrete made with Lehigh Portland cement. The floor slopes 1 ft. from the two sides parallel with the distributing header to the center of the bed, and on it at right angles to the header were laid standard bell end 6-in. vitrified tile pipe split in halves longitudinally and placed with the convex sides up on 10-in. centers. A thin cement mortar was used to bed them well on the floor. The joints between the half pipe were laid open, so as to allow ready access for the effluent, and the pipe was covered with 5 and 6 in. pieces of slag, hand placed.

The half pipe drains to a longitudinal concrete trough parallel to and immediately to one side of the distributing header. The trough is 2 ft. wide, 4 in. deep at the ends and 12 in. deep at the center of the bed, so as to get a good slope for drainage. It is covered with concrete slabs 36 in. wide and 4 in. thick, supported above the half pipe on concrete sills. The main effluent drain connects at right angles with the trough at the center of the bed and runs beneath the filter floor to the final sedimentation basin. It is a 30-in. pipe, made of moulded segmental concrete blocks put together in place in the field with cement mortar.

The bed lies partly above and partly below the original ground level, and the sides in the excavation are built of rough stones plastered with concrete and cement mortar. Above ground the walls are vertical and of dry rubble for about 18 in. above the half pipe, and for the remainder of the distance to the top of the bed of large chunks of slag, having a batter of about 2 on 3.

The slag for the filter was obtained from an old blast furnace dump in Reading and was hauled to the site of the septic tank in bottom dump cars on the Philadelphia & Reading Ry. From this point wagons hauled it to the beds, where a dumping platform with inclined runways at each end was built at the level of the tops of side dump cars running on a track of 30-in. gauge. This track was shifted to different parts of the bed, a turntable being installed when needed. Three spurs were built at the dumping platform so that three cars could be loaded at once. On account of the large quantity of slag required a convenient dumping arrangement was built for the railroad to discharge the slag at the septic tank. The track was carried across on concrete piers, between which was an inclined timber apron that threw the slag out upon a loading platform, built at the height of the bottom dump contractors' wagons, which carried the material to the filter.

The slag was broken to size by hand and screened with forks.

Final Sedimentation.—The final sedimentation basin, built in excavation, measures 100 ft. by 95 ft. 9 in. inside the slopes, which are 1 to 1. Its depth is 4 ft. at the end nearest the filter and 5 ft. at the end toward the river. Since the object of the basin is to allow the sedimentation of the coarse flakes of dried material that have peeled off the slag of the filter bed, it is made quite small, the capacity being about 340,000 gal., sufficient for about 2¼ hr. flow at the maximum capacity of the bed of 3,500,000 gal. per 24 hr.

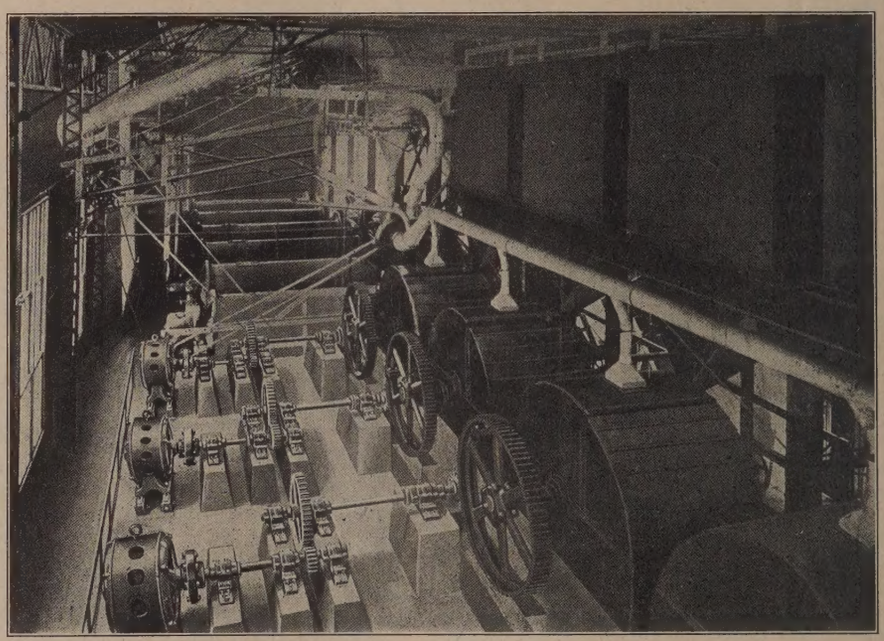
The basin is built of a layer of brick and cobble stones laid on the gravel and loam bed uncovered by the excavation and is plastered with cement mortar to make it tight. The effluent from the filter enters the basin through four ports, or openings with straight vertical sides, from a 30-in. concrete block pipe. It leaves the basin over a concrete weir extending the entire width of the side nearest the river and is then discharged into the stream. A 30-in. pipe by-pass, also of concrete blocks, allows the effluent to be discharged directly from the filter bed to the river.

The plant is being built by Mr. O. M. Weand, of Reading, under the direction of Mr. Elmer H. Beard, city engineer, and Messrs. Hering & Fuller, of New York, consulting engineers. Mr. A. L. Dabney is the representative on the work of the consulting engineers.

Electric Motors for Cement Mills.

By R. B. Williamson.

For driving the various machines used throughout a cement mill, electric motors are now almost universally employed, especially in the more modern mills, such as those for which Allis-Chalmers Co., of Milwaukee, has built and installed the complete equipment, the electric drive having here the same advantages of flexibility and economy that have been demonstrated in so many other lines of work. The elimination of belting and countershafting is specially desirable in a cement mill, where the gritty dust makes the maintenace of belts and bearings expensive.



Induction Motors Driving Ball Mills.

In some mills, particularly those located in the West, power is purchased from transmission companies, but usually each mill is provided with a steam plant of its own. In either case the alternating current system is almost invariably used in modern installations and it may be either 60 or 25 cycles, two or three phase. Although direct current has been used in a few cases, the present practice is to use alternating-current motors almost exclusively for this class of work. The polyphase induction motor has many advantages, not the least of which is the absence of commutator and brushes. The cost of maintenance is less than for direct-current machines, and in the dusty atmosphere of a cement mill, the simple "squirrel cage" rotor of an induction is much less liable to give trouble than the wound armature of a direct-current machine.

In these mills the motors are used for operating rock crushers, ball mills, tube mills, rotary kilns, hoists, conveyors, pumps; in fact, for all the machines used throughout a modern cement plant. In most instances the motors are run at or near full load continuously, and the service as a whole is specially severe. In nearly all cases they are of the squirrel-cage type with short-circuited secondary, a type that necessarily operates at constant speed. For variable speed work the induction motors are provided with a wound rotor, connected, through collector rings and brushes, to an external resistance. By this means the speed can be varied at the expense of lower efficiency. However, collector rings and brushes are undesirable features when exposed to cement dust, and these motors are used as little as possible; they are installed occasionally for operating rotary kilns where a variation in speed is sometimes desirable, and also for electric hoists; but for practically all other classes of work constant speed squirrel-cage motors are preferred.

Probably the most severe service is that demanded of motors for running ball and tube mills. These mills are used for grinding the raw material before calcining, and also the clinker from the rotary kilns. For driving the ordinary size ball mill a 50-h.-p. motor is required, while for a 5x22-ft. tube mill a 75-h.-p. motor is usually installed; a 5½x22-ft. tube mill requires about 95 h.-p. and a 6x22-ft., 115 h. p.; the 5x22-ft. mill is the size generally used.

Ball and tube mills, especially the latter, are difficult to start. The material clings to the sides of the mill, particularly in the tube mill, where pebbles are used to effect the grinding, and at starting the whole mass has to be swung up until the first half revolution has been made. This demands heavy starting torque, usually amounting to one and a half to two times full-load torque. It is desirable, therefore, to use for these mills a motor having starting torque higher than for ordinary service; if this is not done, the motor will take an excessive current at starting, or, if the voltage drops to any great extent, the motor may even fail to start the mill at all. Motors for this service must be of liberal size to give the requisite starting torque and also operate continuously at full load in a dusty atmosphere, without undue rise in temperature. It must be remembered that in cement mills the fine dust gets into the ventilating passages in the motor, and they may in time become clogged up, thus materially increasing the temperature rise.

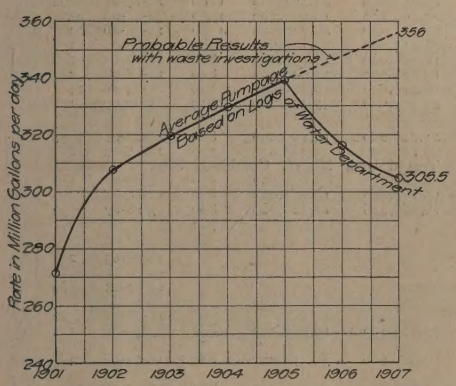
The starting apparatus used with these motors must also be of liberal design in order to carry heavy starting currents. Sometimes the mills are started by throwing the current off and on, giving them two or three swings until they

finally turn over. This is especially hard on the stator and should not be necessary if the motor has ample starting torque. All starters have oil immersed switches for changing the connections from "starting" to "running," and transformers are provided so that a reduced voltage can be applied to the motor at starting, thus reducing the current taken from the line. For this severe starting service where the motors are frequently operated by an unskilled class of help, the starters can be fitted with a device that prevents the handle from being left on a starting position; if left on a starting position it at once returns to the off position, thereby preventing a burn-out of the starter.

Motors for operating these mills are usually belted and run at moderate or slow speed. On 60 cycles, 50-h.-p. motors running at approximately 850 r.p.m. full load have been used for ball mills, but a slower speed motor is more desirable and 670 r.p.m. machines are now recommended. On 25 cycles, four-pole motors running at approximately 700 r.p.m. full load are used.

For 5x22-ft. tube mills a 75-h.-p. motor running at 670 r.p.m. full load on 60 cycles is suitable, while on 25 cycles speeds of 700 or 470 r.p.m. are available, the latter being preferred. Motors are belted directly to the main driving shaft on the mill from which the latter is driven through spur gearings.

As regards voltage and frequency, the majority



Average Total Primary Pumpage in Philadelphia for First Four Months of Year.

of cement mills are operated on 440 or 550 volts and frequencies of 60 or 25 cycles. Although there are instances where 2,200-volt motors have been used, the lower voltages are preferable on account of the greater security of the insulation on the motors and greater safety in working around them. There does not appear to be any settled practice as regards frequency, either 60 or 25 cycles giving satisfactory results; in many cases the frequency is fixed by that of the transmission system from which power is obtained and most plants supplied from such systems are operated at 50 or 60 cycles.

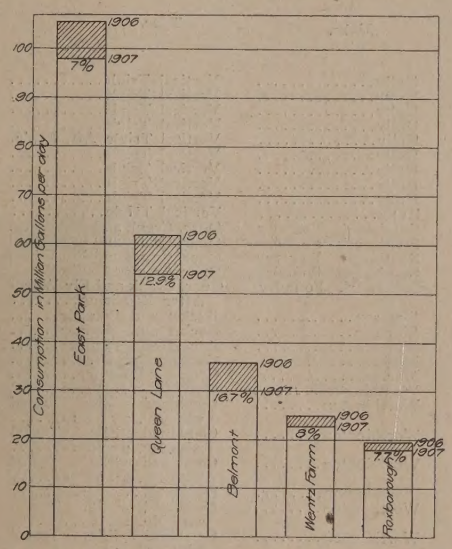
As regards mechanical features, it is important that the bearing sleeves be arranged so that they can be readily removed and relined. All bearings are made as dust proof as possible by means of felt dust guards, and journals are of liberal dimensions.

A NEW USE FOR MOTOR BOATS has been found by the Austrian War Office, which is experimenting with them as substitutes for the iron pontoons used in constructing military bridges. Experience has shown that in building pontoon bridges much time is often lost because the pontoons break loose and must be towed back to position. With motor boats much time can be saved. These boats can be carried on wagons fitted with an inclined plane and a windlass so that the boats can be easily launched and taken out of the water.

Waste-Water Investigations in Philadelphia.

The Bureau of Filtration of the city of Philadelphia started under Major Cassius E. Gillette a broad series of waste-water investigations, which, during the past 20 months that the work has been in progress, have produced a number of exceedingly valuable results. The investigations were undertaken chiefly to determine the following conditions: First, to measure the amount of water delivered by each pump in the large stations in order to find whether the pumps were being operated economically; second, to ascertain whether the reservoirs were leaking; and third, to determine just what becomes of the water after it leaves the reservoirs.

Some work has been done along all of these lines. The investigations of the condition of the various pumps in the large stations were specially far-reaching, and showed that by making comparatively slight repairs the capacity of the pumps could be increased materially. The leakage from the reservoirs was found to be a very small percentage of the total quantity of water pumped. An imperative necessity for detailed waste in-



Decrease in Total Consumption of Five Districts.

vestigation in West Philadelphia and a lack of time prevented any of the extensive tests necessary to trace the entire output of water after it leaves the pumping stations. Although the investigations have been only well started it has been decided to discontinue them for the present, for reasons entirely foreign to the work itself.

The measurements of water were made throughout the investigations with pitometers. During the first year the work was done by representatives of the Pitometer Co., but since January 1, last, it has been under the supervision of the Bureau of Filtration, although conducted by experts formerly connected with the Pitometer Co. The photographic records of flow made by the pitometers and the analyses of these records furnish a great volume of interesting data, but an attempt will be made here to merely outline the results that have been secured.

Pump Tests.—The various pumps in all the large stations were tested to determine the relation between the amount of water actually pumped and the amount indicated by the pump registers, or, in other words, the percentage of slip. The actual quantity of water pumped by each unit was determined by measuring the flow through the discharge pipe of the unit with a pitometer, the duration of the tests ranging from ½ hr. to 24 hr. In most of the original tests, however, records extending over 12 to 24 hr. were obtained; the shorter time tests were usually conducted to check those of longer duration. The amount of slip found in the various pumps tested varied from 3 to 72 per cent. of the registered pumpage. The amount of slip in all the pumps in the city was estimated, from the practically complete results obtained, to average 25 per cent. of the total registered pumpage. That is to say, the amount of water actually supplied to the city is about 75 per cent. of that shown by the pumping records to be furnished.

The results of a typical series of these pump-slip tests are shown in the accompanying Table 1, which covers a number of records made in testing the pumps in the Spring Garden station. The test of the No. 2 unit in this station, a 30,000,000-gal. Holly vertical triple-expansion outside-packed plunger pump, made Sept. 4, 1906, is worthy of special consideration. The actual quantity of water delivered by this pump, as shown by the 24-hr. test, was only 35 per cent. of the calculated displacement; a 12-hr. test of this same unit made shortly afterward indicated that the slip had increased to 72 per cent., that is, the actual output was only 28 per cent. of the calculated. On investigation of the pump valves and valve chambers, it was found that a number of the valves were misplaced and the suction chambers choked to a considerable extent by rubbish brought down the river during a sudden rise in the latter just previous to the tests. No reflection can be cast on the management of the station, however, because the pump was not running lame and presented no outward indications whatever of its serious condition. After repairs requiring less than two days to make, the slip of this pump was reduced to approximately 10 per cent.

The tests of the crank and fly wheel 20,000,000-gal. Southwark Foundry pump, No. 5 unit, in this station should also be explained. This pump on four distinct tests showed a slip varying from 44 to 65 per cent. of the calculated displacement. After an overhauling requiring one day this slip was reduced to 28 per cent., thus increasing its actual discharge by 8,000,000 gal. per 24 hr.

A 30,000,000-gal. Worthington duplex pump was thoroughly overhauled in February and March, 1906. Soon after it had been placed in commission a pitometer placed on its discharge to determine its output showed a slip of 15 per cent. The pump was then shut down to find the cause of the trouble which proved to be a quantity of waste, blocks and so forth that had lodged in the suction chamber and clogged the valves. After this debris had been removed the slip was reduced to 3 per cent.

The results outlined in the table show that the slip of the pumps tested varies between wide limits, the variation often occurring in a very short period. For instance, a single storm in October, 1906, occasioned an increase of slip at the Spring Garden station of 5 to 10 per cent. in each of the pumps. In practically all cases where tests determined large percentages of slip the pumps were considered to be in serviceable condition, judging from the operation. These and many similar service conditions make apparent the necessity for frequent and systematic pump-slip tests.

Reservoir Gaugings.—The outflow from various reservoirs from which the distribution mains are supplied was gauged several times during the tests to obtain accurate data regarding the amount of water furnished to different parts of the city, in order to determine the best distribution of filtered water. The amount of leakage, if any, in the different reservoirs was also measured by pitometer gaugings on the inlet and outlet pipes. The results of these experiments in connection with the Wentz Farm reservoir showed an apparent leakage of 700,000 gal. in 24 hr. A 24-hr. test of the Queen Lane reservoir showed no measurable leakage; the same result obtained with the East Park reservoir.

The data obtained by the reservoir tests fur-

nished a good foundation for a general pitometer survey of the distribution system of the Philadelphia water works. The results also supplied a basis for an interesting comparison of the per capita consumption, which according to the annual reports of the water department, had increased from 160 gal. per day in 1895, to 233 gal. in 1904. After the waste-water investigations were started in September, 1905, the per capita consumption was reduced to 227 gal. per day, and in 1906 to 218 gal. In this connection, it should be noted carefully that these figures are based on registered pumpage, but according to the pitometer measurements showing the large percentage of slip in the pumps—and these measurements are doubtless within 2 to 3 per cent. of being correct—the registered pumpage does not represent the true consumption, although it does represent the true relative cost of pumpage for these years. By pitometer measurements the average daily per capita consumption for 1906 was 165 gal., and during the first part of this year it was 150 gal.

District Tests.—The distribution system of the water-works in the main portion of the city was divided into several districts. Some tests were made in these districts, but the latter were not subdivided and the waste in them carefully traced, owing to the immediate necessity for concentrating efforts to reduce waste in West Philadelphia, where a shortage of water had presented a serious situation. The tests made in these districts were carried far enough, nevertheless, to show that the night rate was disproportionately high as compared with the day rate, indicating a large amount of waste. Practically all of these districts were covered with factories, small residences and tenements. In seven of the districts the night flow was found to be from 70 to 86 per cent. of the day flow. While a few large consumers, such as railroad terminals and factories working day and night, accounted for a portion of the high night rates in one or two of these districts, most of the night flow in the districts was believed to be waste, or unmeasured consumption. The necessity for diverting all the efforts of the experts conducting the waste-water surveys to West Philadelphia to relieve the situation there prevented further work, however, on these districts in the central portion of the city. The flow in the supply lines of certain large consumers was measured, nevertheless, showing in a number of cases very high night rates. Instances were found where practically the entire flow in a pipe line supplying a district would be taken by a single consumer, the night rates frequently equalling the day rates.

West Philadelphia is a residence district with an estimated population of 180,000 and is supplied with filtered water from the Belmont slow-sand filtration plant. When the investigations were started in June, 1906, the consumption was 36,000,000 gal. a day, or 200 gal. per capita, making it evident that considerable water was being wasted. The actual daily capacity of the Belmont filtration plant was determined by accurate pitometer measurements to be only 32,000,000 gal., which is reduced to 29,000,000 or 30,000,000 gal. when the river water is highly turbid. Since the capacity of the filters was not equal to the total consumption, the extension of the district to be supplied with filtered water was dependent on the reduction of waste.

Investigations to locate the waste in the West Philadelphia section were undertaken in a most comprehensive manner. The section was divided into twelve districts, which were of varying size according to the ease of isolating them by cutting off different supply lines and connections of the distribution system. When the consumption of each of these districts had been measured separately with pitometers, it became apparent that the per capita consumption was approximately equally high in all twelve of them. It was also found that the night rates of flow were disproportionately high as compared with the day rates, which, together with the high rates of consumption per capita, indicated that waste was occurring in all parts of West Philadelphia.

In order to determine as nearly as possible the actual night rates of consumption, block by block, throughout the entire section each district was subdivided. This isolation of subdivisions was accomplished by operating the gate valves on the boundary of an area as large as it was possible to cover in a single night so the entire supply entered the area through a single main. The flow in this main was measured by a pitometer, giving the night rate of consumption in the district. This night flow was then localized by a process of elimination, reducing the size of the area, block by block, the time of closing each gate being noted. Each change of flow thus occasioned was registered on the photographic record made by the pitometer, so it was a simple matter to interpret this record later and to determine the rate of consumption for each block.

Table 1, Pump Slip Tests at Spring Garden Station, Philadelphia.

Pump No.	Make.	Type.	Capacity Mil. Gals.	Pumpage, Registered.	Pumpage, Actual.	Gal. Per Revolution.	Date of Test.	Length of Test, Hours.	Slip, Per Cent.
2	Holly	Vertical Triple	30	27,992,000	21,600,000	1080	10-19-05	2½	22.8
2	Holly	Vertical Triple	30	27,760,000	19,900,000	1080	2- -06	24	28.0
2	Holly	Vertical Triple	30	25,033,000	8,700,000	1080	9- 4-06	24	65.0
2	Holly	Vertical Triple	30	27,930,000	7,790,000	1080	10- 7-06	12	72.0
2	Holly	Vertical Triple Aft. Rep'g.	30	25,000,000	22,500,000	1080	10-12-06	12	10.0
	Holly	Vertical Triple	30	24,700,000	20,880,000	1080	5-20-07	1	15.0
3	Holly	Vertical Triple	30	28,493,000	25,495,000	1080	10-19-05	2½	10.5
3	Holly	Vertical Triple	30	27,700,000	19,900,000	1080	2- -06	24	28.0
3	Holly	Vertical Triple	30	26,072,000	20,740,000	1080	10- -06	24	20.0
	Holly	Vertical Triple	30	24,510,000	21,120,000	1080	5-20-07	1	13.0
5	Southwark Foundry	Quar. Crank and Fly Wheel	20	19,906,000	10,764,000	849	10-27-05	1	46.0
5	Southwark Foundry	Quar. Crank and Fly Wheel	20	19,522,000	11,040,000	849	11- 8-05	2	44.0
5	Southwark Foundry	Quar. Crank and Fly Wheel	20	16,310,000	6,990,000	849	10- 4-06	24	56.0
5	Southwark Foundry	Quar. Crank and Fly Wheel	20	21,300,000	7,400,000	849	5-20-07	1	65.0
	Southwark Foundry	Quar. Crank and Fly Wheel After Repairing	20	21,000,000	15,120,000	849	5-22-07	⅔	28.0
6	Simpson	Bucket and Plunger	20	9,792,000	4,445,000	500	11- 8-05	2	55.0
6	Simpson	Bucket and Plunger	20	Tested with No. 7, Combined Slip.					40.0
	Simpson	Bucket and Plunger	20	8,960,000	3,800,000	500	5-20-07	1	58.0
7	Marine	Compound Rotary	20	18,167,000	12,374,000	850	11- 8-05	2	32.0
	Marine	Compound Rotary	20	18,060,000	11,520,000	850	5-20-07	½	36.0
8	Worthington	Duplex				581			
8	Worthington	Combined Slip, Tested with No. 9 and 10					10-25-05	2	13.5
8	Worthington	Combined Slip, Tested with No. 9 and 10					10-27-05	½	16.0
8	Worthington	Combined Slip, Tested with No. 9 and 10					11- 8-06	½	19.0
9	Worthington	Duplex	20	17,460,000	16,060,000	885	3-31-06	1	8.0
9	Worthington	Combined Slip, Tested with No. 10	20	34,916,000	32,270,000	885	10- 4-06	24	7.5
9	Worthington	Combined Slip, Tested with No. 10	20	32,858,000	27,270,000	885	10- 7-06	24	17.0
9	Worthington	Combined Slip, Tested with No. 10	20			885	11- 8-05	½	10.0
	Worthington	Combined Slip, Tested Alone	20	18,720,000	14,820,000	885	5-21-07	½	21.0
10	Worthington	Duplex	30	17,891,000	15,200,000	885	3-12-06		15.0
10	Worthington	Duplex	30	17,820,000	17,300,000	885	3-31-06		3.0
11	Holly	Gaskill	20	20,198,000					

The results of these investigations showed that a house to house examination of plumbing should be made. Accordingly, on July 25, 1906, thirty men started to follow up the pitometer gaugings by inspecting the plumbing in the districts. Although this system of day inspections greatly reduced the waste, it did not curtail all of it, as is shown by the following typical instance. After the first day inspection of a pitometer subdivision of 7 blocks, the night rate of flow was 252,000 gal. per 24 hr., showing that while some reduction had been made the night rate was still high. A second subdivision was made and a special inspection of the service connections was carried on at night with aqua-phones; the connections causing waste were then shut off and were not turned on again until repairs had been made. After this special inspection the night rate of flow in the same subdivision was found to have been reduced to 143,000 gal. per 24 hr.

The result of the pitometer survey in West Philadelphia is shown by the accompanying tabulation of the average daily consumption in that section as measured at various times.

		Gals. per 24 hrs.
March,	1906	35,000,000
June,	1906	36,000,000
July,	1906	57,500,000
September,	1906	35,443,000
October,	1906	31,700,000
November,	1906	29,000,000
January,	1907 (freezing weather)	31,300,000
February,	1907 (freezing weather)	31,600,000
April,	1907	29,000,000
May,	1907	30,000,000

This survey made it possible in October, 1906, to supply filtered water to half of West Philadelphia not so supplied previously and since then nothing but filtered water has been furnished to that section of the city. The necessity for reducing waste over the entire city as rapidly as possible made it advisable to carry forward the investigations without waiting for a complete pitometer survey. Sixty men were, therefore, added to the staff of inspectors in November, 1906, and the inspection work is still in progress. Although this day inspection of plumbing will undoubtedly greatly reduce the waste, the experience has been that the pitometer gaugings permit it to be reduced to a minimum. It is notable that since the inspections were started many premises have been re-inspected and reassessed where no inspections had been made for years.

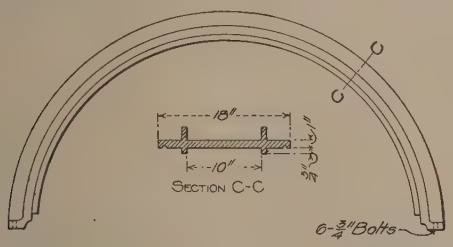
Checking Circular Weirs.—An adjustable circular weir is placed on the 20-in. discharge pipe of each of the filters at the Belmont plant. In order to determine the actual capacity of these weirs several of them were rated with pitometers. Tests of these weirs when the plant was discharging 19,000,000 gal. a day indicated that they were over-rated about 10 per cent.; several tests under a discharge of 29,000,000 to 31,000,000 gal. per day for the plant showed these weirs to discharge 5 per cent. less than their rating.

General Results.—In addition to results that have been noted as accomplished by this waste-water survey, many unexpected conditions of the water-works system as a whole, as well as the distribution system, have been revealed. The reduction in waste which has been accomplished is indicated by two accompanying diagrams. One of these diagrams shows the percentage of decrease in the total consumption of the five districts into which the water-works system is divided. The heavily shaded portion at the top of each of the areas representing the consumption for the different districts shows graphically the actual saving in that district, based on the average daily consumption for similar seasons in 1906 and 1907 from gaugings of reservoirs and main supply lines with pitometers. It may be noted that the greatest percentage of reduction was made in the district where the waste-water survey was most completely carried out, and the least, where

the smallest amount of survey work was done.

The second diagram is a curve showing the average total registered primary pumpage for the first four months of each year from 1901 to 1907, inclusive, this period being chosen in order to include the figures for the present year. Since this curve is based on the average registered pumpage, and the amount of water supplied to the city is actually 75 per cent. of these quantities, due to an average slip of 25 per cent. in the pumps, the points on the curve are all high. The curve as plotted, however, has the same general shape and represents practically the same percentage of saving, the registered pumpage values being taken in order to follow the logs of the water department from which the data was obtained.

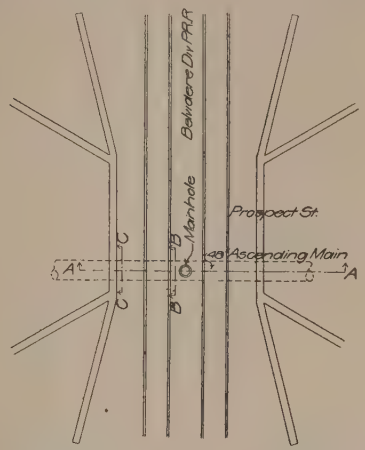
The data from which these notes have been compiled was furnished by the Bureau of Filtration of Philadelphia, Mr. Fred C. Dunlap, chief engineer, and by representatives of the Pitometer Co.



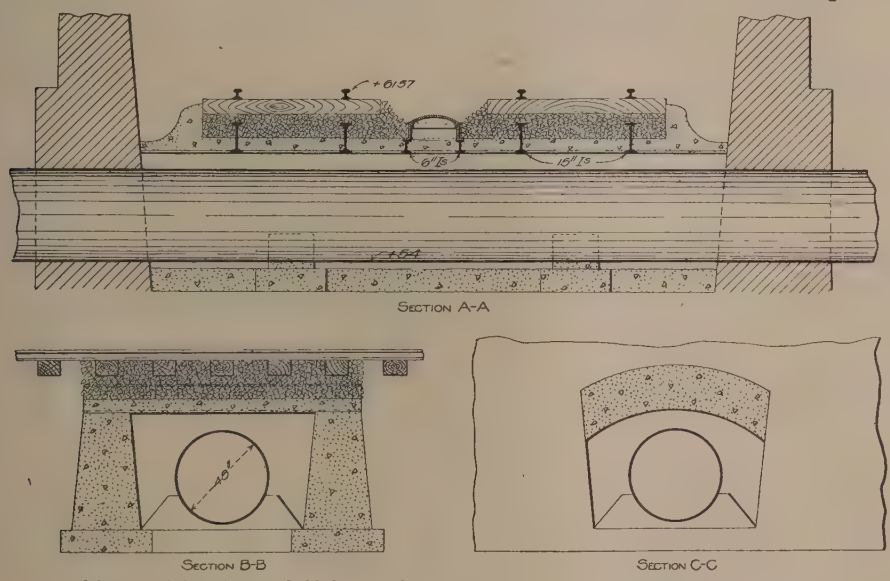
Cast-Iron Sleeve for Reinforcing Water Main.

Carrying a Steel Water Main under a Railway.

A 48-in. steel main under construction in Trenton, N. J., in connection with the improvements to the water supply system of that city, has been carried under the tracks of the Pennsylvania R. R. and the Delaware & Bound Brook R. R., under conditions requiring special construction to protect the pipe from excessive earth pressure and the jar of passing trains. The pipe, which is of the lock-bar type, is made of 5/16-in. plates and is delivered in 30-ft. sections so as to reduce the field joints to the lowest number possible. Sleeve-hub and lead joints are used, and at all bends these are reinforced with heavy cast-iron sleeves, of the form shown in an accompanying illustration, put on over the regular sleeve and and calked with lead in the usual manner.



Plan of Water Main Crossing.

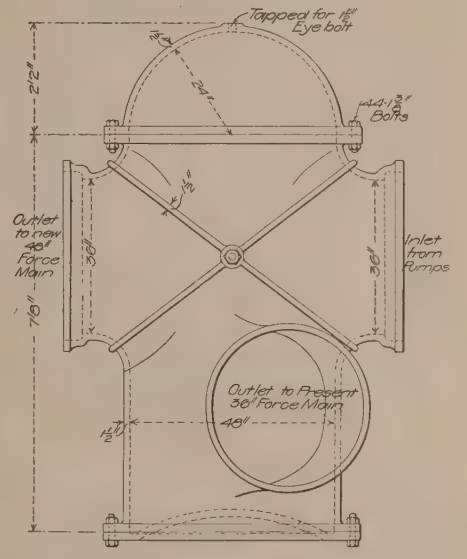


Plan and Sections of 48-Inch Pipe and Tunnel under Railroad Tracks.

For some distance the 48-in. main is laid along a street which passes over the Belvidere division of the Pennsylvania R. R. on a steel structure with stone masonry abutments. Here the pipe has been carried through the lower part of the abutments and under the tracks, with its top about 3 ft. below the base of the rails. Depressing the pipe below the tracks necessitated trenching from 10 to 27 ft. in depth, both approaching and leaving the bridge. Where the depth of trench exceeded 10 ft. it was thought unwise to depend on the ordinary steel pipes to carry the weight of the back-filled material. A cast-iron pipe might have proved satisfactory where the depth of trench was excessive but it was found that a steel pipe in a concrete tunnel would be no more expensive and even more satisfactory, owing to the ease with which it could be inspected and repaired if necessary.

The tunnel extends about 150 ft. above and 300 ft. below the bridge and consists of two heavy concrete walls carrying a 12-in. slab of plain concrete reinforced by 10-in. I-beams, except under the tracks where a 15-in. I-beam is placed under each rail, as shown in the accompanying illustration. Where the pipe passes through the opening at the bottom of each abutment a concrete arch was sprung across the top of the opening as a precautionary measure. Access is had to the tunnel through a manhole under the bridge between the tracks and through one at each end of the tunnel. A drain connecting with a sewer leads away from the lower end of the tunnel. The passageway is lighted with electric lights for which current is taken from the street lighting system, a switch being provided to make the connection when the tunnel is entered. The construction used in carrying the pipe under the tracks of the Delaware & Bound Brook R. R. is like that already described.

The connection of the new main with the reservoir is to be accomplished by inserting a stayed cast-iron Y-special in the present 36-in. ascending main within about 200 ft. of the present inlet. The leading end and one leg of the Y is to be the present line of main, and the other leg of the Y is to be connected with a 48 to 36-in. reducer, and then the 48-in. reducer is to be connected with the new ascending main. There is to be a gate valve, 36-in. and 48-in. respectively, provided for each of the ascending mains immediately back of the Y, so as to permit the use of either main separately or both together.



Special Connecting New and Old Mains.

Mr. Newton A. K. Bugbee is the contractor for the ascending main, the plans and specifications for which were prepared by Mr. Chas. A. Hague, of New York City, consulting engineer. Mr. Alvin Bugbee is superintendent of the Trenton water works.

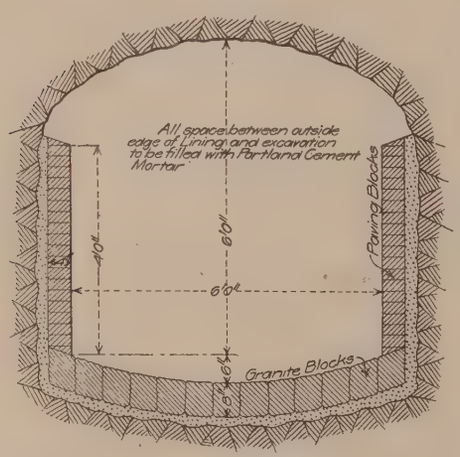
Asphalt Production in the United States in 1906 amounted to 138,059 short tons, valued at $1,290,340, as against 115,265 short tons, valued at $758,153, in 1905, an increase in 1906 of 20 per cent. in quantity and of 70 per cent. in value. Of this amount 24,085 tons were bituminous sandstone, 2,543 tons were mastic, 24,178 tons were hard and refined asphalt or gum, 9,900 tons were liquid asphalt or maltha, 12,947 tons were Wurtzilite and Gilsonite, 1,952 tons were Grahamite, and 62,454 tons were oil asphalt, according to the U. S. Geological Survey. The great increase in the production of hard and refined (or gum) asphalt in 1906 over that of 1905, which amounted to only 3,036 short tons, is due chiefly to the new refinery development in Texas, although the production of this variety in California in 1906 (8,178 short tons) is 100 per cent. in advance of the total for 1905. In the production of oil asphalt California stands almost alone, producing 62,361 short tons of the total quantity and showing a substantial increase over 1905. The Texas output is very small. Trinidad supplies about two-thirds of the American consumption.

The Hardening of Hydraulic Cements was the subject of a voluminous paper read a few months ago before the Society of German Portland Cement Manufacturers by Dr. W. Michaelis. His conclusions are that hydraulic cements will be the more reliable and the more durable, the more limited the process of crystallization during their hardening, and hence he prefers cements low in alumina and lime. The surplus lime crystallizes and favors the formation of calcium sulphoaluminate in the presence of aluminates and sulphates, he states, or the surplus lime is dissolved and carried off and in consequence the cement becomes porous. The alumina forms unstable crystals of calcium aluminate and, in the presence of sulphate solutions, the undesirable calcium sulpho-aluminates.

A Large Sewer Project in St. Paul, Minn.

The provision of a sewerage system for an area of 2,500 acres in the western part of St. Paul, which area is largely a manufacturing district that is developing very rapidly, involves several engineering features of large magnitude. The district is more or less rolling and has its surface drainage nearly all tributary to one watercourse. This watercourse is dry during a part of each year, but at times carries a large volume of water. The outlet of the watercourse is in the Mississipi River, which is about 150 ft. lower than the sewerage district and about one-half mile from the latter. The sewerage system is on the combined plan, the two main sewers which serve the district joining at a deep drop shaft in the bed of the watercourse; a tunnel, 2,500 ft. in length, extends from the bottom of this shaft to an outlet in the Mississippi River. The tunnel is finished, the drop shaft is approaching completion, parts of both main sewers have been built and the contract for the completion of these mains and the extension of the lateral sewers is to be awarded soon.

The 2,500-ft. tunnel from the river to the drop shaft has vertical sides, an arch roof and a curved invert, as shown in an accompanying illustration, its extreme height being 6.5 ft., and the clear width 6 ft. It was built entirely in excavation in a dense sandstone rock. The bottom is lined with 8-in. granite blocks laid in cement mortar, and the sides to a height of 4 ft., with vitrified paving blocks, also laid in cement mortar. The space between the lining and the excavation is filled with mortar. The tunnel is on a 1.4 per cent. grade throughout its entire length, so that the velocities through it are high and its capacity is quite large.


All space between outside edge of lining and excavation to be filled with Portland Cement Mortar
Paving Blocks
6'0"
Granite Blocks

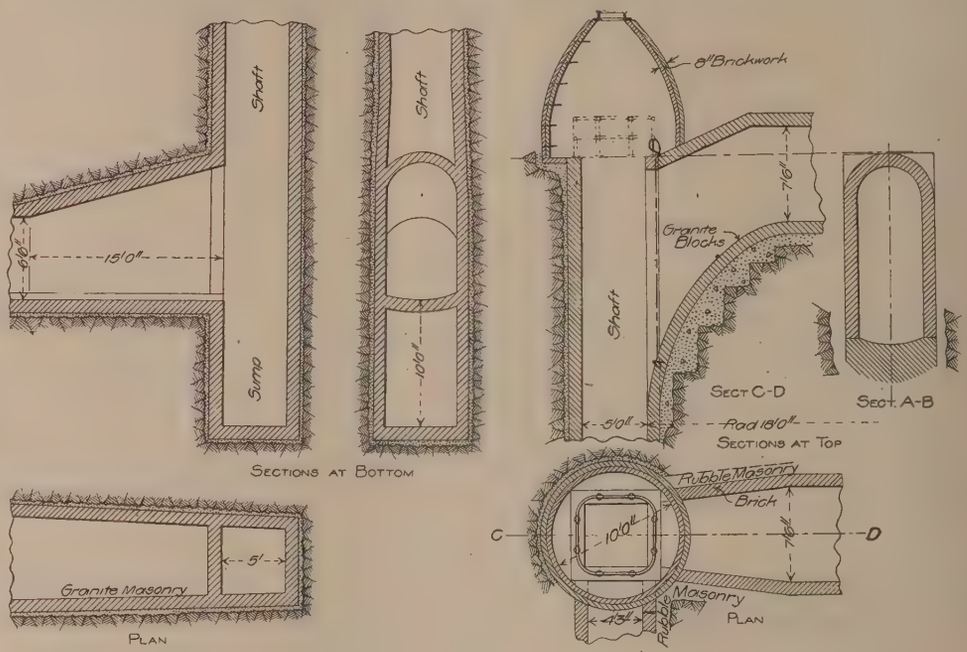
Cross Section of Outfall Sewer Tunnel.

The construction of the tunnel presented no unusual features, as the excavation was made through the sandstone without much difficulty. Work was started at the river end and driven through to the drop shaft. The excavated material was hauled back to the mouth of the tunnel at the river in small cars. From 2 to 4 men were generally engaged at the working face while the tunnel was being driven, one shift being employed. The tunnel was completed at a contract price of about $5 per linear foot.

The engineering work done during the construction of the tunnel is worthy of notice. The tunnel has a curve at the drop shaft and the alignment had to be carried forward from a single backsight. When the curve on the tunnel at the drop shaft had been run the center line of the tunnel intersected a 6-in. drill hole which had been put down on that line during the preliminary investigations made to determine the location of the tunnel.

The drop shaft has a total depth of 125 ft. from the ground level to the bottom and is 5 ft. square inside the cut-stone granite masonry with which it is lined. The two main sewers connect with the drop shaft near the top and on adjacent sides. One of these sewers is 7.5 ft. and the other 4.25 ft. in diameter up to the connections. The cross-sectional area of both sewers is increased at the connections and the side of the drop shaft is continued up as an arc of an 18-ft. circle to its junction with the invert of the sewer. The calculations that the flow of the sewage into the drop shaft will thus be diverted more directly down the shaft. The arcs of the circle at the connections are also lined with granite blocks to take the wear due to the high velocity of the sewage over them.

A sump, 10 ft. deep below the tunnel invert, is placed at the bottom of the drop shaft, so the sewage entering the latter will always fall on a water cushion. The outlet from the drop shaft into the tunnel is a large bell-mouth, 15 ft. long, which is designed to permit a maximum quantity of water to enter the tunnel.



Plan and Sections of Drop Shaft at the Upper End of the Outfall Sewer Tunnel.

The granite lining of the shaft ends just above the connections with the main sewers, or about 11.5 ft. below the ground surface. A bell-shaped manhole, 10 ft. in diameter at the base, is to be built from the top of the lining to the ground level. This manhole will be closed with a sealed cover, to prevent large pieces of debris entering or being thrown into the shaft. It is expected also that the shaft will rarely, if ever, have to be repaired owing to the very substantial way in which it is built.

The construction of the shaft has been carried on under exceedingly difficult conditions. The upper 20 to 21 ft. of ground at the site is ordinary glacial drift, below which is a depth of about 22 ft. of fine water-bearing sand containing some clay, which made it a very limpid quicksand. Under this quicksand was a thin layer of clay immediately overlying the sandstone rock through which the tunnel was driven. An excavation, 20 ft. square, was first opened at top and was lined with heavy wooden sheeting thoroughly braced and cross-braced. An attempt to carry the excavation through the quicksand in this manner failed completely, the contractor finally abandoning the work after the excavation had collapsed in the quicksand. The board of public works then assumed control of the work and has carried it practically to completion.

The timbering and sheeting in the collapsed portion of the excavation were first removed in order that a new method of handling the work might be started. United States steel sheet piling in 20-ft. lengths had been obtained meanwhile and was driven through the quicksand in such a way as to form the sides of a 10-ft. square. After the sand enclosed by the steel sheeting had been removed, the masonry lining of the shaft was then built up rapidly to avoid, as much as possible, any danger of the quicksand causing a blow-out. The steel sheeting held, however, under the great pressure brought on it and the lining was finished without any mishaps.

The excavation for the balance of the shaft through 35 ft. of rock was next carried down to the bottom of the sump. A steam drill, supplied with steam from the boiler of a hoisting engine at the mouth of the shaft, was used to make blast holes. Light charges of dynamite were exploded in these holes, without injury to the masonry lining which had been completed. The excavation thus made in the rock was smaller than that made for the portion of the shaft above the rock, so the lining already placed would not be disturbed. It was then trimmed out, commencing at the bottom, and the lining carried up to the top of the rock.

An 1,800-ft. length of the larger main sewer and a short section of the smaller one have been built. The 7.5-ft. sewer was built of three rings of hard-burned brick, and the 4.25-ft. one of two rings, all laid in cement mortar. Contracts for the extension of the 7.5-ft. sewer for 4,000 ft. in a 7-ft. circular reinforced-concrete section and the 4.25-ft. section for 3,500 ft., also in reinforced-concrete, are to be awarded soon. The lateral sewers leading from the mains will also be placed under construction at once.

The design and construction of the sewerage system for this district are carried on under the supervision of Mr. L. W. Rundlett, commissioner of public works of St. Paul. The sewer department is under the immediate direction of Mr. A. R. Starkey, assistant commissioner of public works, who has personally directed the construction work handled by the city.

A Long Railway Tunnel will be built on the Midland Railway of Australia under Arthur Pass, the total length being about 28,000 ft., or about 5¼ miles. The contract has been let to J. McLean & Son. The section will be 17 ft. high and 15 ft., lined throughout. The material through which the tunnel will be driven is solid rock.

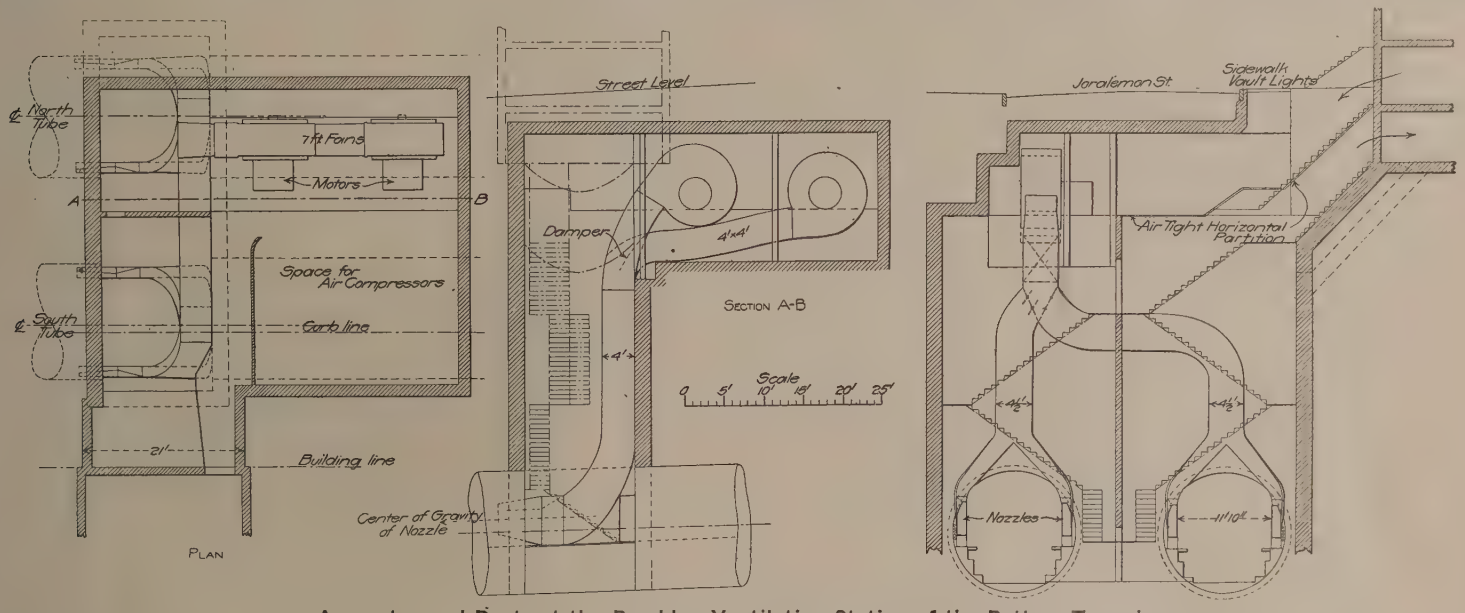
Ventilation of the Battery Tunnels of the New York Subway Extension to Brooklyn.

The two tunnels under the East River from Battery Park, Manhattan, to Joralemon St., Brooklyn, of the Brooklyn extension of the New York Subway System, have been practically completed and satisfactory progress is now being made with the work of their equipment, preparatory to the beginning of operation of trains within a few months. The subaqueous connection has been built as two single track parallel tubes, running from 26 to 28 ft. apart on centers and about 6,750 ft. in length. The tubes are cylindrical cast-iron shells, lined with concrete, having an inside diameter of 15½ ft. and they were projected toward the center of the river with gradients of 3 1/10 per cent., which are united at the lowest point near the center of the river by a vertical curve, with the tops of the tubes about 80 ft. below mean high water level in the river. The details of the construction of these tubes have been referred to in a number of articles in The Engineering Record, notable among which are those in the issues of June 2, September 29, and December 22, 1906.

Owing to the length of the tubes and the restricted clearances within them when trains are in operation, some provisions for their ventilation were foreseen to be necessary, particularly in case of trains becoming blocked or stalled in the tubes. Under ordinary conditions of operation, it is expected, from the general experience in operation of trains through tubes of similar sections, that the piston action of the trains passing at frequent intervals in the same direction through each tube will suffice for all ordinary requirements for ventilation. This action of draft induced by trains in motion is, in fact, to be largely taken advantage of for ventilation, large openings to the tubes having been made at the shore ends to permit of free access of air behind all trains as they leave either side and correspondingly for discharge from in front of trains as they come up out of the tubes. But in order to provide adequately for any emergency conditions that might arise, it has been thought advisable to install a carefully planned system of mechanical ventilation which may be used continuously, if required, and which shall always be in readiness for emergency, sufficient reserve equipment being provided for this purpose. Owing to the length of the tubes and the character of the service to be handled through them, the conditions attending the problem of ventilation are without a doubt the most difficult that have ever been encountered, and the selection of a satisfatcory design was rendered far more difficult by the lack of precedent in application to conditions of this character. Owing to this a very careful study of the problem of tunnel ventilation was necessitated and the design was finally selected which embodies the more important features of the best practice in tunnel ventilation in this country and abroad.

Experience in the ventilation of railway tunnels where the smoke and gases from steam locomotives are to be dealt with, have indicated that the most effective ventilation may be secured where both ends of the tube must of needs remain open, by blowing air into them through jets or nozzles and in the direction of movements of trains. This method of tunnel ventilation will, in the case of a slow, heavy freight train, drawn by locomotives emitting dense black smoke, drive the gases ahead of the train and keep the atmosphere clear and comfortable for the train men to work in. While the difficulties of smoke and gas are not here encountered, the requirements for ventilation are analogous, it being necessary to keep the atmosphere within the tubes frequently changing by driving a considerable volume of air through them, and essential that ample ventilating capacity be available in an exigency such as a stalled train. This method of ventilation was accordingly adopted, but difficulties of considerable magnitude were, however, encountered in securing convenient and proper location for the blower equipments near the ends of the subaqueous sections of the tubes and also of installing nozzles of sufficient size in the restricted spaces available in the tubes, to provide an effective blast. It was thought advisable to provide narrow nozzles on either side of the tubes in the spaces available above the bench lines which could thus be from 15 to 16 in. in width without restricting the clearance limits over trains and at the same time leave sufficient space next to the sides of the tubes on the horizontal diameter lines through which to pass a limited number of feeder cables or wires. With the requirement for admitting the blast in the direction of train movements, it was obviously necessary to install blowing stations on either side of the river, and a convenient location for the blower station was available on the New York side under the corner of Battery Park near the ferry stations, but a great deal of difficulty was encountered on the Brooklyn side in securing an available site in proximity to the water front. The most suitable location would, of course, have been one like that on the New York side, near the bulkhead line, but it was found impossible to secure rights on any of the water-front property or even in the first or second blocks nearest the river; only after a great amount of trouble and considerable litigation was an available site secured, which is at No. 58 Joralemon St., a private residence on the south side of the street and in the third block up from the river front.

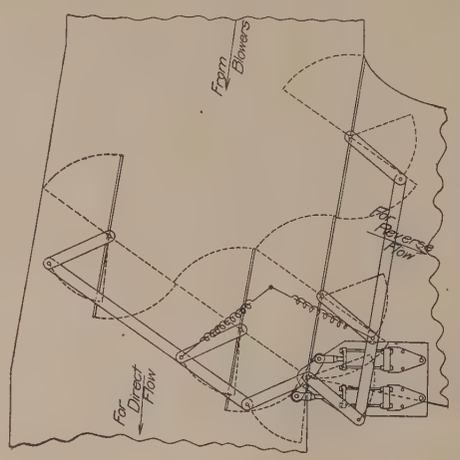
After a careful study of the problem, the engineers in charge of the design decided that a volume of from 45,000 to 50,000 cu. ft. per minute should be introduced into either tube for the results desired with provisions for a slight increase over this amount for emergency conditions. With the space available for nozzles, however, the areas of the orifices were limited somewhat, which factor, of course, largely influenced the capacities of blowers selected. The nozzles although designed as large as possible for the spaces available are but 15⅜ in. wide x 4 ft. total height, the upper corners being cut off by the upper portion of the tube shells, and have each a total cross sectional area of orifice of 5 sq. ft. Each tube thus has a total capacity of nozzle orifice of 10 sq. ft., each of the nozzles being supplied with air from the blowers through a converging connection from a delivery duct of 18 sq. ft. cross section. The blowers selected as best adapted to this duty with these particular sizes of connections were centrifugal downward-discharge fans with 7-ft. wheels, 4 ft. in width. Operated against a static pressure of 0.33 oz. blast, each fan has a capacity for delivering 46,500 cu. ft. per minute. The blowers are all ¾-housed steel plate centrifugal fans built by the American Blower Co., and 2 units are installed in duplicate at each blower station, it being thought that with this provision of reserve capacity, no combination of conditions will ever arise in which at least one unit cannot be kept in running order in each station. Each of the blowers is direct-connected to a 75-h.p. C. & C. interpole motor which is designed for operation on the 600-volt current from the third rail of the Subway propulsion system, and is fitted with control apparatus for a speed variation from 300 to 413 r. p. m. The source of supply has, also, been made doubly by the extension of an independent feed for the purpose from the substation of the S... nearest to the blower stations, and a ... nection to the third rails in the adj... although the latter will serve as a ...



Apparatus and Ducts at the Brooklyn Ventilating Station of the Battery Tunnels.

connection only and will not be used under ordinary conditions. They are also fitted with automatic starting switches arranged for distant control, so that the blowers may be placed in operation upon an instant's notice from the office of one of the despatchers of the Subway lines.

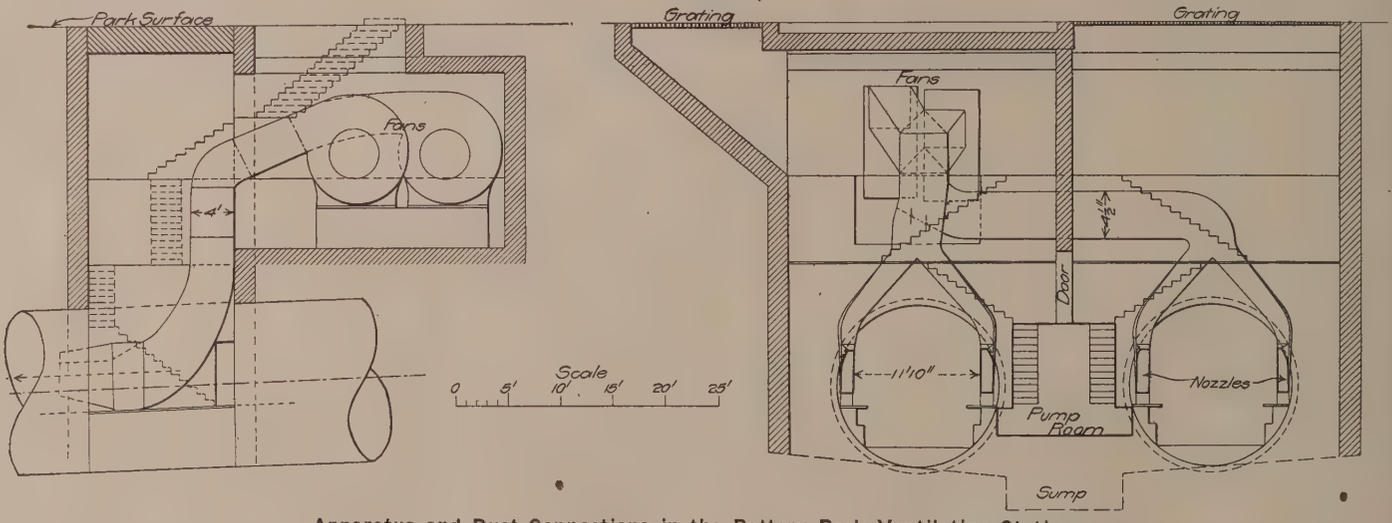
The interior arrangements of the blower stations and the apparatus and duct work are shown in the accompanying drawings. Each station consists of an underground chamber located near the surface, in which the blower and motor-drive equipments are located, and connecting with which are vertical shafts, 14 ft. in width, that are carried down to openings in both of the tunnel tubes. These shafts vary somewhat in longitudinal dimensions, being about 52 ft., inside, at the Battery Park station and but 45 ft. at the Brooklyn station, owing to the restricted width of Joralemon St., at that point. That in the Joralemon St. station is much the deeper, the tops of the tubes being there 48 ft. below the street level owing to a considerable elevation in the ground level at that distance back from the river front, while at Battery Park the tops of the tubes are but 25½ ft. below the surface. The shafts are divided vertically through the middle by partition walls so that the openings to either tube are independent and either may thus act as an exhaust chimney or flue from its tube for the discharge of air which is blown through or is driven out by the piston-action of the trains; in normal operation, however, this exhaust action will take place from the south tube at the Brooklyn station and from the north tube at Battery Park only, as the trains are to be operated on the usual "right handed" plan. The shafts at either end are arranged to be left permanently open to the outer air, the opening at Battery Park consisting of an irregular shaped grating of 252 sq. ft. area, directly over the shaft and that on the Brooklyn side, of a large passage which extends up into the building alongside of the station which was purchased for this purpose; this passage is 14 ft. wide and approximately 9 ft. in depth, and connects with a large opening up through the building into the outer air. The blowers have intake from the outside air through their operating chambers in the stations, that at Battery Park having an opening to the surface through a 252 sq. ft. grating, similar in shape to that for exhaust, while at the Brooklyn station a passage, 4 x 6½ ft. in cross-section, leading into the Joralemon St. building made use of, through which air will be drawn an opening at the rear. Access to the chambers as well as also to the lower e shafts are had by means of flights rs conveniently arranged, as shown in anying sections of the stations connections from the blowers to the imply arranged, consisting in general of a vertical rectangular duct of No. 18 galvanized iron, which extends from the delivery outlets of each group of two fans directly downward to the tube through which air will normally be blown, with cross branches to the other sides of the shafts to connect with the reserve nozzles for reversal of the flow in the tubes, if this may be necessary in emergency. The down delivery ducts are of 18 sq. ft. cross section which is ample to carry the maximum volume that can be delivered through the nozzles, and they divide over either tube, through a Y-connection, into two branches of 9 sq. ft. section which supply the two nozzles, the branches and connections to the nozzles being similarly proportioned and shaped on either side in order to equalize the flow from either nozzle. The blowers deliver through connections of 16 sq. ft. cross section which join at the top of the shaft into the down delivery ducts, special flap dampers being used at the joining to permit either blower desired to deliver independently, while in case it is desired to operate both blowers together, the dampers will assume a central position and thus not interfere with the delivery of either unit. The choice of these sizes of ducts is due to the fact that the capacity of the system is limited by the areas of the nozzle orifices, upon which the design of the blowers was based; the effect of the nozzles is such that even with the second blower in operation, the volume delivered through them would be increased but to a slight extent, probably not over 20 per cent. The control of the delivery to the nozzles in either tube is had through sets of louvre dampers in the ducts at points immediately beyond the joining of the cross branch to the vertical duct, which dampers are interconnected and so actuated that the blowers cannot deliver into the nozzles of both tubes at the same time; these damper mechanisms in the two stations are furthermore fitted for distant electric control, by means of which the interlocking arrangement is secured, and which also permits of instantly changing the direction of flow in both tubes from a distant point.



Interlocking Damper Mechanism.

One of the most interesting features of the blower installation is the above provisions for distant control of the dampers, as much study has been given to the matter of providing means for instantly adjusting the conditions of ventilation to the requirements of any emergency in the tunnels. Under all ordinary conditions of operation, it is expected that all requirements for ventilation will be met by the above-mentioned plan of directing the blast in the direction of train movements, i. e., eastward in the south tube from the Battery Park station and westward in the north tube from the Joralemon St. station, but with the heavy traffic that will be operated through the tunnels, an emergency may at any time arise, such as a stalled train or deranged electrical apparatus, in which it may be desired to quickly reverse the direction of flow of air. For this purpose the control of the dampers has been placed in the charge of the despatcher in the Bowling Green interlocking tower of the subway lines who is at all times in direct communication with all parts of the tunnels by means of a series of telephone stations, distributed at intervals of about 300 ft. throughout either tube; in case of any trouble reported to him he may thus instantly reverse the direction of flow, if necessary for the comfort of the passengers or workmen.

The distant control mechanism is of the electro-pneumatic type, the electrically-controlled pneumatic cylinders built by the Union Switch & Signal Co. for actuating signal mechanisms being used. As these cylinders are of the single-acting type, two are installed at each blower station, one for throwing the dampers in either position. They are mounted side-by-side on the side of the duct near the dampers and have their pistons connected to a rocker arm, pivoted at the middle, which carries a bell-crank so connected to the louvre dampers as to always maintain one closed while the other is open. The angles which the louvres assume when closed were so chosen in relation to the directions of flow that but about 60-deg. of movement of the vanes is required, and in order that the cylinders or levers may not stick in a partly opened position, positive throw spring attachments have been applied to the levers of either louvre which will always ensure completion of the motion of opening or closing, provided the cylinders throw the mechanism more than half way over. The electric air valves that control the pneumatic cylinders are actuated by the regular 16-volt direct-current supply for the signal sytem, a double-throw switch at the Bowling Green interlocker tower controlling both sets



Apparatus and Duct Connections in the Battery Park Ventilating Station.

of cylinders; when thrown in one direction, it actuates simultaneously the cylinders in both blower stations for the direct flow, while in the other direction, the cylinders for the reverse flow. In this way the adjustments of the sets of dampers are positively interlocked and it is thus rendered impossible through mistake to direct the blast into both ends of either tube at one time. No provision has been made for directing the blast in the same direction through both tubes at the same time.

The provisions for ventilation thus made enable a great variety of conditions to be met. Under ordinary conditions, it is, as above stated, expected that the air in the tubes will be maintained sufficiently clear for the comfort of the trainmen and passengers by the piston-action of the trains passing through, while, if in hot summer weather, more ventilation should prove desirable for cooling purposes, the operation of one of the blower units for either tube will add considerably to the effect of the trains. It is, however, in the case of a serious emergency that the full value of the ventilating equipments would be realized. While there is no danger from fire in the tunnels, as cars of metallic construction only are to be operated on the Brooklyn extension, the smoke that would result from a burnt-out motor or other derangement of the electrical apparatus of the propulsion system could incite a serious panic amongst passengers; such smoke or obnoxious gases in case of a stalled train can, with the blowers in operation, be rapidly dissipated, and, by virtue of the provisions for reversal of flow, in such a manner as to be least offensive to the people at the scene of the accident. If, for instance, an accident of serious nature should occur to a train before it had reached the mid-point of the tunnel, the shortest distance of exit for the passengers would be in the direction from which the train had come, so that the regular flow of air in the direction of train movement would carry the smoke and gases in the opposite direction; if, on the other hand, the train had passed the mid-point of the tunnel when the accident occured the quickest exit would be toward the train's destination and a reversal of the flow of air would facilitate the same. By means of the system of telephones in the tubes, the trainmen may very quickly advise the despatcher if the reversal of flow is necessary, which is accomplished in the office of the latter by the mere throwing of a single-pole switch. Furthermore, if the blowers should happen not to be in operation, they could be instantly started by the mere throwing of another switch at the same point, one for either blower station, the blower motors being, as above stated, fitted with automatic starting equipments with distant control.

The ventilating system for the tunnels and the equipment were designed by the late Board of Rapid Transit Railroad Commissioners, of which Mr. Geo. S. Rice was chief engineer and Mr. D. L. Turner general inspector of stations. The details of the electrical devices were in charge of Mr. H. N. Latey, of the firm of Latey & Slater, consulting engineers to the late commission.

The Amabele-Butterworth Railway, South Africa.

The Amabele-Butterworth Ry., in the eastern part of Cape Colony, South Africa, one of the newest branches of the Cape Government Railways, starts from a station on the Eastern System about 50 miles from East London, an important town on the Indian Ocean. Its total length is 78 miles, but the central portion of the line from Komgha to Ndabakazi, 41 miles, is the only part interesting from an engineering standpoint, both the first part from Amabele to Komgha, and the last part from Ndabakazi to Butterworth, passing through easy country. From Komgha to Ndabakazi the road traverses the mountainous country of the Kei and Toleni Rivers, making it one of the heaviest lines in the Colony.

A short distance from Komgha, which is 27 miles from Amabele, the road starts down, from an elevation of 2,260 ft. above sea level, on its descent to the Great Kei River, the country traversed being very mountainous, and necessitating heavy earth work and masonry. At 39¼ miles from Amabele it became necessary in order not to exceed the maximum grade to build a spiral encircling a conical hill, and passing under itself through a short tunnel. This spiral is the only one on the Cape Government Railways. Between the spiral and the Great Kei River heavy earth work and a number of long culverts were necessary.

Mountainous Portion of the Amabele-Butterworth Railway.

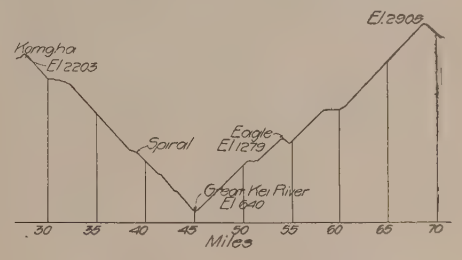
The distance from Komgha to the Great Kei River by railroad is 18 miles, though it is only 7 miles in a straight line and 11 miles by wagon road. This development was necessary in order not to exceed the maximum gradient of 1 in 36 or about 2.8 per cent. The difference in elevation between the two places is 1,563 ft., Komgha being 2,203 ft., and the river bridge 640 ft. above sea level.

The Great Kei River is crossed on a temporary timber bridge consisting of 22 spans of 25 ft. each. Owing to a difference in rail elevation of 21.95 ft. between the future permanent bridge and the present temporary one a switchback was put in, the line approaching it being built in a permanent position. This switchback lies almost entirely on a 2½ per cent. grade, is 3,000 ft. long and has a maximum curvature of 17 deg. 22 min.

East of the Great Kei River the ascent to Ndabakazi is commenced. For some distance the line follows up the valley, then rounds back 180 deg., by means of a 17 deg. 22 min. curve, and runs on the same side of the hill above the other line, until the Manqulu Valley is reached. At this point the upper and lower portions of the line are about 900 ft. apart horizontally, though the distance along the track is about 4 miles. Following up the valley to near its head the line crosses the Manqulu River on a viaduct of four 50-ft. spans, the rail level being about 51½ ft. above the river bed. The bridge is on a 2 per cent. grade and a 17 deg. 22 min. curve. After leaving the Manqulu River the line crosses over the divide to the Toleni Valley at Eagle, and from this point on the most difficult work is found. Heavy embankments are necessary and in one instance a rather complicated drainage system in which two culverts unite into one under the bank. The line for some distance hugs the precipitous cliffs that fall almost shear to the Toleni River, about 400 ft. above the water, and in this stretch a great length of retaining wall was built. Two tunnels, one 351 ft., and the other 578 ft. long were driven through projecting spurs. The Toleni River is crossed on a bridge of two 100-ft. spans.

The total quantity of earth work, exclusive of tunnel excavation, is 1,598,000 cu. yd., which omitting the last three miles near Ndabakazi, since they contain neither fill nor excavation, amounts to 42,000 cu. yd. per mile. With the exception of three cuts through rock and disintregated ironstone, nearly the whole of the work is loose shale, both soft and hard, with occasional ledges and boulders of solid rock. In one section, a mile in length, nothing but very hard rock was encountered. Various explosives were experimented with but dynamite gave the most satisfactory results.

Toward the completion of the work concrete arches with stone faces were adopted for culverts because of the saving in masonry and time of construction, but most of the openings under the track are built of hammer-dressed coursed rubble laid in cement mortar. Wherever possible, culverts have been placed high up in the bank to save masonry, drains being extended up into the



Profile beyond Komgha.

draw from the bank to catch the water. The total number of openings under the track including bridges, culverts and iron and tile pipe, is 366, or 8.9 openings per mile. At mile 55 the line crosses a deep double gully on a high bank. A culvert has been fixed in each gully and they join under the embankment into a common outlet. One culvert falls one in seven and the other, one in three, the roof of the latter being stepped down. The length of the present construction measures 133 ft., and had two separate openings been built the total length would have been about 260 ft.

In an endeavor to reduce the quantity of concrete used in one of the culverts a special design was drawn up for an 8-ft. semi-circular arch. The side walls battered one in five and the invert was curved. The length of the culvert was 13.1 ft., and the quantity of concrete 207 cu. yd., or a little over 7 cu. yd. per lineal foot.

The sand for the concrete had in general to be hauled quite a distance, such material as was found close to the various culverts being of poor quality. The sand that has given the best results is a sort of rotten ironstone found close to the main road in the Kei Valley. This was put in bags and conveyed by wagons to the various culverts. Trials were made of sand from the Great Kei River but as a rule did not give satisfactory results. In some places it was found difficult to get water for mixing the concrete and at one point it had to be carried up by men a distance varying from 200 to 300 ft. above the river. The total quantity of masonry in the 41 miles is 28,050 cu. yd., an average of 684 cu. yd. per mile.

There are three tunnels on the section of the line from Komgha to Ndabakazi, the shortest, the

one on the spiral, being 66 ft. in length and meriting no special description. It is on a 17 deg. 22 min. curve and as the formation was a soft shale it was lined with masonry. Tunnel No. 1 is 352 ft. long and lies entirely on a 14 deg. 28 min. curve. Tunnel No. 2 is 679.8 ft. long, the greater part of it being straight and the end on transition curves. The straight section is 527.4 ft. long. The cross section of both tunnels is 14 ft. wide on the straight portions and 16 ft. 4 in. on the curved portions. Shelters are provided every 66 ft. alternately on either side of the tunnel. The material in tunnel No. 1 is a very hard close grained rock and the lining for the walls and the arch is 18 in. of concrete. In tunnel No. 2 the nature of the rock is variable. The section through the softer rock will have a 24-in. concrete wall with an 18 in. arch, and where the harder rock is encountered the thickness of the wall will be reduced to 12 in. The drain in tunnel No. 2 will be in the center, but in tunnel No. 1 will be placed on the inside of the curve against the side wall.

Owing to the comparatively short lengths, the work of setting out these tunnels was not difficult. In tunnel No. 1 the first portion of the curve was discarded for driving purposes and a sub-tangent fixed at the mouth of the tunnel, the length of this sub-tangent being 231 ft. Although tunnel No. 2 commences and ends on transition curves, it was just possible to clear the sides of each entrance and run a straight line through, offsetting the curves. Two chains or 132 ft. from the Komgha entrance to the latter tunnel the line was crossed by a gully into which a cross cut heading was driven, meeting the center line 39 ft. from the face of the mountain. By this means 4 faces were worked at one time.

The rails are second-hand, weighing 60 lb., and the ties are of treated jarrah wood 7 ft. 10 in. long and 5 in. thick, 11 being used to a 30-ft. rail. The joints in the latter are laid square on the tangents and staggered on curves. The minimum depth of ballast below the ties is 5 in. The ballast used is a disintegrated granite found along the road. Track laying and ballasting is done by contract at $25 per chain of 66 ft.

The maximum curvature is 17 deg. 22 min., all curves sharper than 10 deg. 52 min. being transitioned, the length of the easement being 105.6 ft. The maximum grade is 1 in 36 or about 2.8 per cent., compensated 0.035 per degree of curvature. The maximum super elevation is 4⅞ in.

The work was done in short contracts varying from ½ to 2 miles in length, according to the quantities of earth work or masonry and the ability of the contractor. As a rule the earth work and masonry were let to different men, but experience showed that to combine the two under one contract was more satisfactory. The average price for earth, measured in excavation and including a free haul of 528 ft., varied from 56 to 68 cents per cubic yard. Solid rock varied from 87 cents to $1.00 per yard, and tunnel excavation from $5.00 to $6.20 a yard. The average cost of masonry was $11.95 per yard, concrete $11.08. The total cost for the 41 miles was $2,209,135, an average of $53,881 per mile.

The survey and the location of the line were made by Mr. A. M. Tippett, chief resident engineer for the Cape Government Railways.

Steel Ties will be used on the Bessemer & Lake Erie Railroad next year according to recent plans. About 70,000 ties will be necessary for renewals and repairs in place of wooden ties now in use, the lines on which they will be used aggregating 90 miles. The United States Steel Corporation during the present year has sold about 3,000 tons of steel ties, and on the roads it controls about $500,000 worth are in use, sufficient for about 160 miles of track.

Earth Slides.

Mr. H. Rohwer, formerly chief engineer of the Missouri Pacific Ry., has contributed to a recent bulletin of the American Railway Engineering and Maintenance of Way Association some notes concerning earth slides which are based on his long experience in railway work. After pointing out the fundamental fact that slides are formed when masses become disconnected, and hang on a slope steeper than the plane of friction due to the character of the material and its ability to resistance, he states that water being one of the most influential elements in reducing this resistance to a minimum, it is well to provide for proper drainage before slides set in. The golden rule is to "keep the water away from the roadbed." The study of geology is frequently overlooked by the engineer having charge of location, and he gives but little attention to the possibility of encountering slides caused by either the grade or location of line. If drainage is of so much importance, why not place the line, circumstances permitting, where drainage can be rendered most effective, allow sun and wind to act upon the roadbed, and pay close attention to the manner of constructing it?

When delegated to investigate the cause of slides in an embankment of one of the main trunk lines in the Middle West, constructed about the year 1861, Mr. Rohwer found the slopes considerably deranged. The embankment, about a quarter of a mile in length and over 22 feet high in the middle, was continually settling, and notwithstanding the attention given it by the operating department, this evil continued to exist. Trackmen, when called upon to remedy similar breaks, usually apply stone, which on account of the greater weight, increases rather than diminishes the evil and the cause of the slide is thereby not removed, in Mr. Rohwer's opinion. The method employed not being effective, piles were driven and a bridge constructed along and over the fill for such distance as was deemed necessary. As the piles did not rest in original ground, they swayed to and fro, and the maintenance of the line and grade became a matter of great annoyance and cost. About the time this pile bridge required renewal, Mr. Rohwer was asked to make an investigation of the trouble and to recommend what should be done to improve the safety of the road, and, if possible, prevent the slides and dispense with the trestle.

In digging a trench on each side of the track along the foot of the slope and parallel with the track, considerable seepage from the bank poured forth, leading to the belief that the water was retained in the bank by some cause or other, and was seeking an outlet. Mr. Rohwer then had intercepting drains constructed, extending towards the center of the embankment at intervals of 25 to 50 ft., according to the amount of water apparently confined in the embankment. The drains were then filled with stone—the heavier at bottom and the lighter on top—covered with cinders. This method accomplished the object of draining the embankment and rendered it stable so that the trestle could be removed, and no further difficulty at that point has been experienced.

In prosecuting this work, the drills were extended into the center of the embankment, and it was discovered that a number of partly decayed logs were embedded therein. Upon inquiry it was ascertained that the contractor at the time of construction had logs hauled in at night. The earth on the outside covering up this deception, the water was retained in the inside of the embankment, softening the material dropping into it, and with the heavier material on top, was forced to the sides, and thus creating slips or slides. In the case above cited, the slide sounded a timely warning, so that the proper remedy could be employed. However, crevices formed under the roadbed are much more dangerous, the latter producing slides without giving notice, this often being the case where the roadbed rests on the debris hanging on the side of bluffs, especially when bordering on a treacherous stream like the Missouri River.

Water coming down ravines can be readily conducted across the roadbed by bridges or culverts, but in such cases care must be exercised as to outlet. However, water falling on the sidehill between ravines or creeks and dropping from bluffs into the debris where it cannot readily be intercepted, will enter the roadbed, penetrate the underlying loose strata and find its way over and along the harder strata, thus creating the earth slides to which reference has been made. This water keeps the ground under the track in a constant moist state, a menace to the safe operation of the road. Oftentimes it will form crevices, and when once formed they will increase and may reach to the very surface, only to be discovreed after a wreck has occurred, and are then usually termed "a washout." Again, the water may soften the material until it becomes slushy and will produce a slip at the foot of the lower slope. Borings made by Mr. Rohwer over a distance of seven miles on parts of tracks so situated showed that the roadbed developing such defects was invariably located directly against a bluff or perhaps resting on material underlaid by slanting rock, which rock forming a part of the bluff, had been eroded by the action of the water, either river or surface, or both combined.

If the water is collected at frequent intervals and conducted across the track either by means of small boxes (if pipe cannot be utilized) or conveyed in open ditches plastered with cement or rammed with small stone so as to prevent the water from penetrating into the roadway, the danger referred to can be greatly diminished.

The most remarkable slide coming to the notice of Mr. Rohwer was encountered on the White River Ry. at the entrance of a long tunnel, its magnitude precluding all thought of removing it. The disturbance first manifested itself at what might be termed a sidehill cut. In removing the footing, the mass of clay seemed to lose its hold on the rock whereon it rested, and began breaking off, first showing cracks insignificant in size and their location being confined to the right-of-way, but later reaching far out into the adjoining hills, bringing down trees and forming breaks in the surface 15 to 25 ft. in height and perpendicular in appearance.

The Omaha tunnel, 2,650 ft. in length, penetrates a sag in the Ozark Mountains, consisting of a so-called boulder formation, lime and rock being found intermixed with clay, a hydrated silica of alumina of brownish color, due to the presence of iron oxide. This clay is very plastic, especially so in the approaches where action of water is not constant, as in a tunnel. Here the layer of clay was from 5 to 100 ft. thick, underlaid with strata of solid rock of smooth surface and slanting at an angle of from 5 to 10 degrees toward the creek, along which the line had been located, then in course of construction. The grade of the roadbed entered the rock 20 ft. below the surface; in other words, the approach to the tunnel has a 20-ft. rock cut with clay in the slope overlying it.

As soon as cracks appeared on the surface, extra precautions were taken against surface water. The surface ditches were given steeper grades, and, where possible, bottoms were cemented so that the water could drain off more quickly, thus reducing chances of penetration to a minimum. In spite of this the ground continued to break and started to move toward the open cut, at first dropping into it little at a time, gradually increasing until after a rather heavy rain the

entire cut filled up with this stuff, involving an expenditure of one dollar per cubic yard for its removal. Though the moving masses had adopted a slope of nearly two horizontal to one vertical, the breaks continued, stretching for more than 150 ft. into the hill above the grade of the roadbed, and over 500 ft. distant from it.

To prevent similar occurrences during the time of operation, involving delay and expense, Mr. Rohwer had the rock cut arched over for a distance of 600 ft, from the portal of the tunnel. But an arch, framed of timber in order to furnish clearance, without protection against side pressure, cannot be relied upon as a permanent safeguard against slides. To make it serve, however, should the mass continue to move, the clay bank was removed for a distance of 12 ft. from the edge of the rock cut and holes were drilled into the rock 8 to 10 ft. in depth, and from 10 to 15 ft. apart in a row along the foot of the new bank, shots being placed therein and fired simultaneously by means of an electric battery. The rock was broken but not scattered, a trenchlike crack appearing at the surface. The writer then had logs cut from the timber, of which an abundance was found in the immediate neighborhood and these logs were placed alongside each other with the butt end in the rock crevices, the other end overhanging the timber arch, and resting upon its top. The material under the logs and between the logs and the arch was tamped, thus forming a solid flooring over which the material could slide, as was contemplated, distributing it over the entire arch and serving as a weight instead of a thrust.

The further object of cracking the rock was to permit the water coming through the clay to escape, thus leaving the footing dry and in better position to act as a support. The plan worked very satisfactorily. The first rain produced another slide, the logs carrying the material over the arch. With the drain in the rock at a distance of 12 ft. from the edge of the cut and over 30 ft. from the foot of the new slope, a good foothold had been created which served the purpose, for no further movement of the overhanging masses, estimated by the engineer in charge as reaching the enormous quantity of 130,000 cu. yd.; has taken place since that time, 1904. The few sticks of timber in the arch which had moved, were displaced not more than an inch.

This experience led Mr. Rohwer to the conclusion that many similar slides formed by masses moving along a rock surface might be checked by boring holes down to rock, lowering dynamite and breaking the surface by means of blasts and actual practice has confirmed this view.

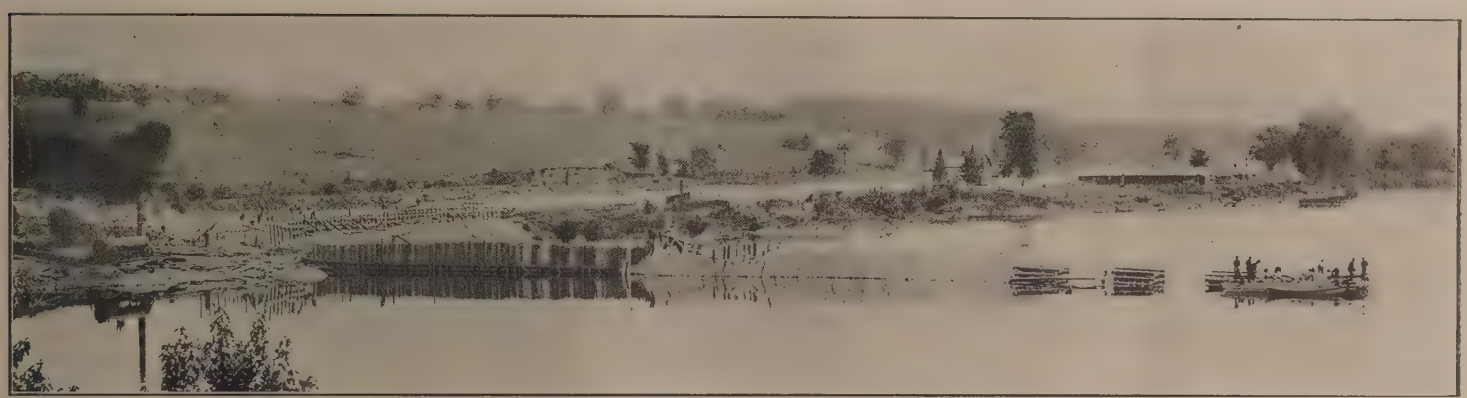
An Investigation of Manhole Explosions at Aberdeen, England, disclosed the fact that coal gas leaking from street mains may become odorless by filtering through a moderately thick layer of earth without losing its explosive effect.

Crocker's Reef Dam across the Hudson at Ft. Edward.

By Herbert Spencer, C. E.

For the improvement of the Champlain Canal, extending from Waterford to Fort Edward, via the Hudson River, and from the latter place to Whitehall, on Lake Champlain, a series of dams will soon be in course of construction. The Crocker's Reef dam across the Hudson River is the first of this series to be constructed, and will serve to maintain the Barge Canal level for a distance of seven miles.

The accompanying views and sketches show the main features of the work and the methods employed by the contractors during construction. The dam is in two sections, the east spillway being 480 ft. long, and the west spillway 280 ft. long. The bottom of the river is rocky on both sides of the island, the rock being a shale formation, very common in this locality. One of the illustrations shows the lay-out of the east channel, with the sections; the west channel is similar, except that the abutment walls are not so long.



Method of Placing and Filling Cribs for Coffer-Dam; Crocker's Reef Dam.

Work was started on the dam proper on May 24, 1906, the contractors excavating the rock with pick and shovel. The section of the dam called for the neat line of the excavation to be on the back line of the dam, and that the concrete skewback should butt up close against the rock. Drills were set about 2½ ft. back of this cutting line, and after the holes were fired the rock was picked off to a neat line. A trench about 2 ft. deep was thus dug out of the rock, care being taken to secure a good rock shoulder against which the concrete could butt. The excavated material was thrown outside of the coffer dam on the downstream side, and helped weight down the sheeting and keep it in place.

As the water was shallow for about 150 ft. out from the east shore, it was decided to build a puddled coffer dam on the upstream side. The coffer dam consisted of 8x8-in. timbers, 5 ft. apart horizontally and 2½ ft. apart vertically, separated by ½-in. round bars with square nuts. The truss was braced by 4x4-in. vertical posts 5 ft. apart, and 4x4-in. diagonals. Two rows of 1-in. plank were then placed on the inside of this coffer dam on each side. Sand bags were placed at the bottom and clay puddle was placed inside.

The material for the puddle was taken from the canal prism just north of the dam, and consisted of a clayey mixture, with considerable earth mixed in. The downstream side was treated by placing two rows of 1-in. sheeting against the stringers at the south end of the trestle timbers. Sand bags were then thrown on the bottom and clay dumped in until it was well up on the sides of the sheeting. One of the illustrations shows a section of the coffer dam, and the arrangement of the track overhead.

At Sta. 2+20 of the line of dam it was decided to substitute a crib coffer dam in place of the interior puddled dam. This was on account of the deeper section encountered, and it was also thought to be more economical.

The cribs consisted of rough hewn timbers, mostly maple and elm, which were all cut from the spoil banks further up the river. The cribs were framed on shore by placing one log upon another, log house fashion, and drift-bolting with ½-in. pieces of iron. One of the illustrations shows a section of these cribs. On the inside was nailed 2-in. plank to hold the stone with which they were sunk.

When a crib was framed on shore it was buoyed up by placing empty oil barrels in it and towed out to place. Guy ropes anchored to trees on shore assisted in letting it down to the proper location, when it was lined up and sunk. A large raft loaded with stone always accompanied the crib, and when it reached its anchorage the stones were thrown in. Owing to the swift current it was difficult to always hold the cribs in place, and considerable care and ingenuity had to be exercised to sink them at the proper place.

A large crib 50 ft. long was framed on shore to close the last gap between the rest of the cribs and the island, and was floated to place in the usual manner. Unfortunately, the water was too swift and the guy ropes broke, allowing the crib to float downstream. It was with difficulty recovered and brought back to place. At this latter place a depth of water of 28 ft. was found, and the crib had to be sunk here. This depth was not looked for, as the cross-sections did not extend upstream far enough to take in the hole. However, it was successfully done, and a small wing crib placed at an angle to deflect the strong current away from the deep hole.

Three separate coffer dams were used to cross the east spillway and as soon as enough cribs were in place 8 x 8-in. timbers were placed on the upstream side to connect them. These were securely fastened to the crib, and the sheeting was then run down to the bottom. Two rows were used, one-inch plank for the shallow water and two-inch plank for the deeper sections. These plank were nailed to the waling pieces connecting the cribs, and as soon as they were in place the maneuvering boat was placed close by, and sand bags were guided by two poles held by hand until they settled on the bottom. These were firmly rammed in place, and all large holes at the bottom chinked up.

Clay was next brought over from the prism excavation in ¾-cu. yd. dump cars, three cars to a train load, and dumped on a platform. Shovelers then threw the dirt over the sides and it slid down the sheeting and settled at the bottom, closing all joints between the planks. The downstream side was made secure by placing sheeting against the two ends of the trestle timbers, and throwing in dirt until it almost reached to the top of the dam.

The first section of coffer dam, about 130 ft. long, was pumped out in 17 minutes, and no trouble at all was encountered by leakage. In fact, all the coffer dams were exceptionally well built, and very little leakage occurred in any of them.

The trestle was built as the coffer dam progressed, and consisted of upright posts 9 in. in diameter, spaced 12 ft. apart. Across the top of the posts were placed rough timbers smoothed on only two sides and projecting over the posts about 2 ft. These were fastened, both longitudinally and transversely, and were also braced against the rock-filled cribs. Ties were placed on top of the trestle, and a 3-ft. gauge track the mixer prepared to start the loaded car off again.

An actual timing between trips showed an interval of about seven minutes, and that two minutes was taken to dump the car. The length of time it took to dump was due to the fact that the car, being an ordinary dump car, was not suitable for this work, as the concrete could not slide out fast enough. The bottom was covered with a large sheet iron plate, and the corners plastered with sand, so that very little mortar could run out going from the mixer to the dam.

Points were given at intervals of about 20 ft. on the bottom of the large curve for setting the forms. A string was stretched between these points and the bottom of the curve brought to this line. Ribs were made out of 2-in. plank and spaced 5 ft. apart. These ribs were fastened by cleats to the trestle overhead and braced against the rock at the bottom, and the forms nailed on this curve. Ribs were also made for the small curve at the crest, and ¾ x 2-in. lagging nailed on. The line for the crest at the correct elevation was given, and the small ribs brought to this line after allowing for the lagging to be nailed on.

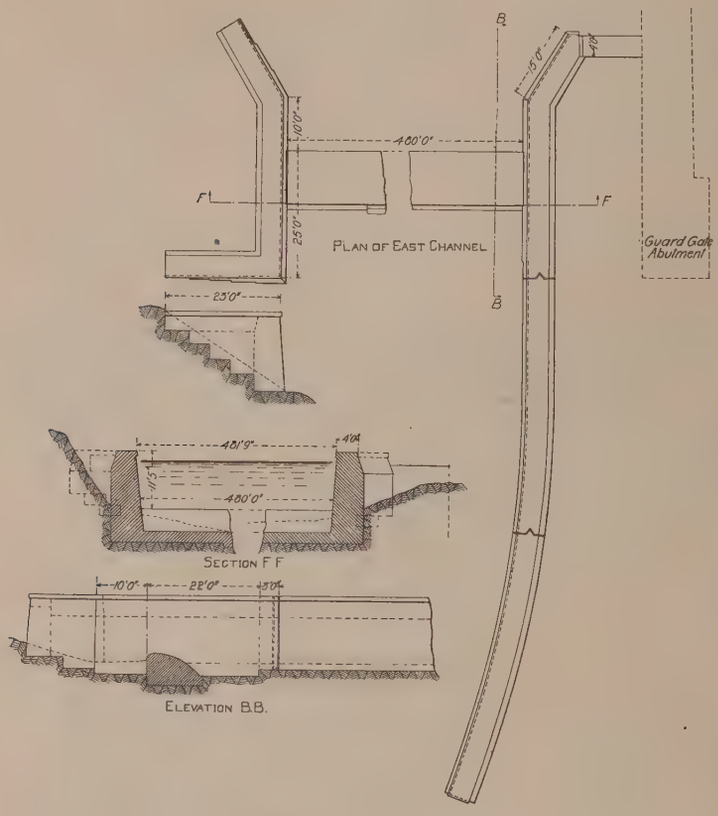
The slope below the larger curve was given by a template, and the tangent to the curve made by nailing pieces of 2-in. plank to the ribs and allowing them to rest against the rock at the bottom. The forms were then nailed to these straight ribs as far as the level of the rock.

The concrete was allowed to run out from inside the forms and fill the space between the rock and the bottom of the forms. This was the simplest and easiest way to construct the skewback, care being taken to see that the concrete had a close bond to the rock shoulder of the foundation.

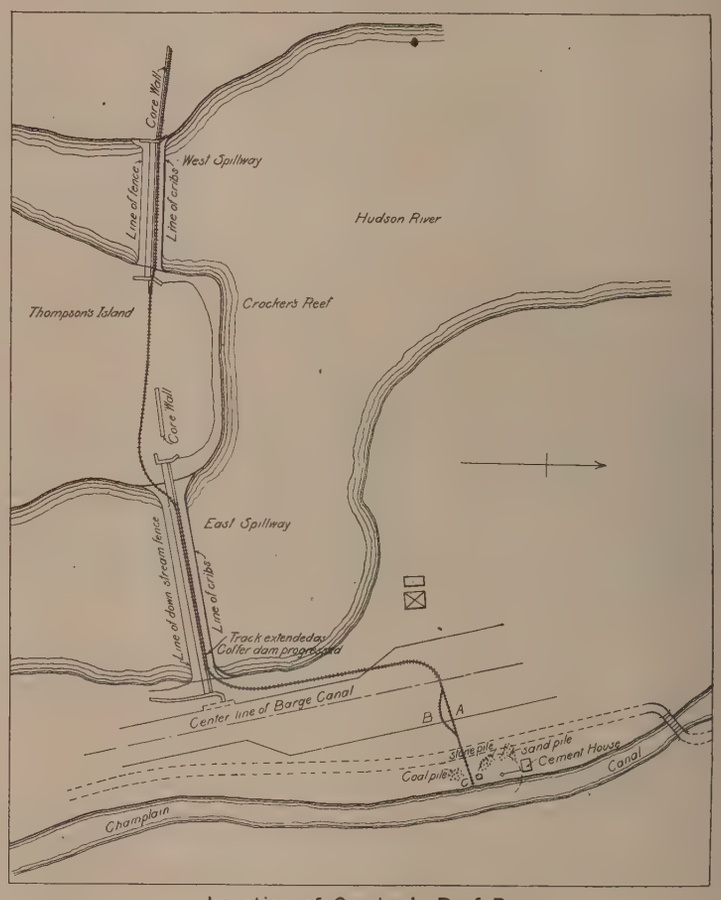
Large stones about 1 cu. ft. in size were placed in the dam, spaced 12-in. apart. About ten per cent. of the dam consisted of these stones. On account of the flat curve of the dam it was difficult to ram the concrete against the forms, and only enough plank were placed to keep abreast of the concrete. By this method the men in the dam could use their forks to pry back the stones.

The abutment walls for the spillway were well bonded into the rock on each side, the elevation of the top being taken 2½ ft. above the maximum high-water stage. The core walls on the island and on the west mainland are of concrete, with an earthen embankment 16 ft. wide on top and covering the top of the wall to a depth of 2 ft.

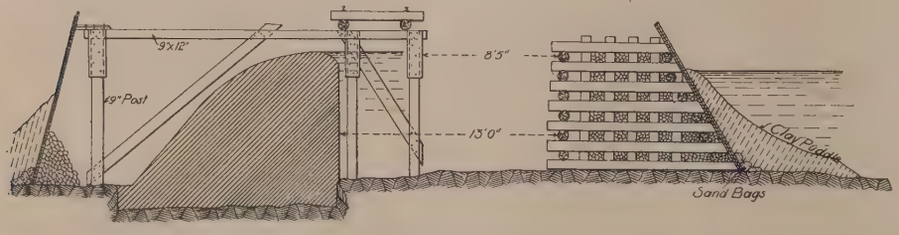
The dam was started the latter part of May, and completed about Oct. 10, 1906. The total length of crest is 760 ft. The contractor was the Empire Engineering Corporation of New York.



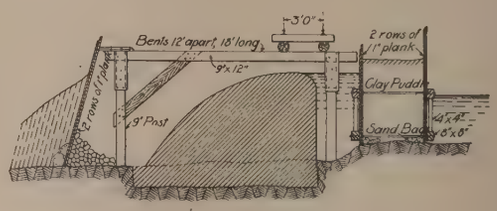
Dam across the East Channel.



Location of Crocker's Reef Dam.



Arrangement of Crib and Trestle for Use in Deep Water.



Arrangement for Shallow Water.

Back-Filling Trenches.

A paper by George C. Warren, President of Warren Brothers Co., before the Detroit convention of the American Society of Municipal Improvements.

It is pleasing to note that recent issues of engineering periodicals have devoted prominent space to this matter, which is both one of the most important and one of the most generally neglected matters that municipal officials and contractors have to meet in connection with street work.

One of the articles referred to quotes from specifications of the West Park Commissioners, of Chicago, which are incorporated in permits granted for making excavations in streets to reach underground service pipes. From the quotation the following extract is of special interest:

"All material excavated from any trench under paved roadways must be removed from the boulevard; said trench being refilled with clean cinders, sand, gravel, or crushed stone, placed in layers not exceeding 6 in. in depth, thoroughly compacted with heavy hand rammers, using the necessary amount of water to complete perfect consolidation of the back filling."

This specification is certainly on the safe side, but for general use in many, if not most cases, it seems to the writer unnecessarily severe and expensive in the requirement that all material excavated from any trench must be removed from the street and replaced by cinders, sand, gravel, crushed stone, etc.

In the case of West Chicago Park Boulevards such a general stipulation may be justified by either:

(a) The importance of not littering the boulevards any more than absolutely necessary and of maintaining their fine appearance as constantly as possible, or

(b) The knowledge, if it is a fact, that the sub-soil underlying this section of Chicago is of a character which, after once being disturbed, is unsuitable for backfilling of trenches. Whatever may be the reason and justification for such a claim by the Chicago West Park Commission (and I assume it is justified there), this should not be set out as a generally suitable provision and for all cities and all classes of sub-soil. I do not want to be understood as advocating the withdrawal of one iota of the greatest precaution and care in this important matter of backfilling of trenches, carelessness in which is costing an aggregate of hundreds of thousands of dollars annually in damage to pavement and vehicles. On the contrary, my purpose is to endeavor to point out the importance of the matter and to suggest practicable, general requirements for overcoming the difficulty in the most economical way as to each particular case.

With a quarter of a century of experience in street paving throughout the United States and Canada, I believe I have met the matter of backfilling of trenches in about all of its possible phases, and I appreciate that it is a most difficult matter to draft a specification which will give (a) efficient results and (b) a basis of payment for the work which will insure the greatest practicable economy to the city and fairness to the contractor.

Completed Section of Crocker's Reef Dam with Work in Progress beyond It.

The greatest difficulty arises from the fact that the method of treatment and its cost vary very widely with the character of sub-soil, which often varies very greatly within the limits of one sewer or water or gas main trench; this often cannot be foreseen and often varies with the weather conditions (wet or dry) which happen to prevail.

Before attempting to offer a solution I will mention a few instances which have come to my notice. There is a popular notion that trenches should be allowed to settle for a year before paving and that then the work is safe. This is not only a fallacy which breeds carelessness in cases where it is thought no pavement will be laid in a year or more, but it is impracticable to defer paving until a year or more after all mains and house connections are made, and equally impracticable to avoid cutting into pavement for installation of and repairs to service pipes, although the latter can be guarded against by the exercise of reasonable precaution much more than is generally done.

We all know that by careless or indifferent backfilling of trenches unpaved streets are often rendered dangerous and nearly impassable for years. I remember about fifteen years ago an instance in one of our older cities, where an asphalt pavement was being laid, replacing an old cobble pavement. The cobbles and a few inches of the underlying earth necessary to provide the sub-grade were removed; the sub-grade rolled with a steam roller, and a concrete foundation laid. While the concrete was "setting" there had been a good deal of rain, and at one point in the street the concrete settled and developed a hole, into which a hoe handle was inserted the full length without finding the bottom of the hole. Investigation and subsequent examination developed a serious hollow, several feet deep, about 2 ft. below the surface and over 200 ft. long, over a sewer which had been laid twenty-five years before and doubtless backfilled in what is still the quite generally customary way of merely throwing the earth loosely back into the trench. In this case a crust or arch of solid earth had become formed, which did not develop the hollow below until the excavation for the new pavement removed a part of this crust, and the rains caused the balance of the crust in one spot to fall into the hole. In another instance no trouble developed in the construction of an asphalt pavement laid on concrete foundation, but three years later a horse's hoof broke through the surface of the pavement and he broke his leg. Here examination revealed a hole 6 ft. deep, which it took fifty loads of earth to fill, over a sewer trench ten years old.

It is very common for a pavement to settle a year or more after it is laid along the line of a sewer trench filled several years before the pavement, where no trouble developed during the rolling and laying of the pavement. It is still more common to find almost insurmountable difficulty from settlement of old trenches while the paving work is in progress.

So much for the theory that however carelessly a trench or other fill is made it will settle itself within a year. On the other hand, I have never known of a case where trouble has followed from the settlement of sewer or service pipe trenches made immediately before the laying of the pavement where I had supervision of the backfilling, even with very treacherous soil conditions. I would far rather take my chances on the guarantee of a pavement laid immediately after a sewer trench, the filling of which I could control, than five years after the laying of a sewer, the trench of which was filled with the generally customary carelessness and usual view to the least possible cost only.

About two years ago I was going over a street about two miles long in the Middle West, for the paving of which bids were about to be received. A sewer, the trench of which was from 15 to 20 ft. deep to a clay soil, was being built, using an excavating machine, which backfilled without tamping. On account of the looseness of the fill the level of the roadway over the trench was being raised about 18 in., sloping to nothing near the edge of the road. An inspector was standing over the work, and I asked him to show me the specifications. They clearly provided for "thorough tamping of the trench in courses, not more than 6 in." On calling the inspector's attention to the provision he first claimed that it only referred to paved streets. I showed clearly that this was not the case and explained that my interest in the matter was as a bidder and possible contractor for the pavement to follow, and received the following retort: "You don't shuppose Misther Murphy (naming the contractor) is going to fill the sewer for youse!" The outlet of the same sewer passed through a paved street, which I found was actually being filled, without any tamping whatever, with tipcarts loaded from the excavation by buckets and hoisting engines. An appeal to the engineer brought a promise to investigate any continuation of the trouble, and

further inquiry brought out the explanation that this provision of the specifications was not generally complied with; that contractors did not figure on doing so; that the price showed the contractor did not figure on doing so, and that it would be a hardship to force him to the expense, and that as the pavement would not be laid for a year, the trench would probably be settled by that time. This is only a somewhat aggravated case of what happens to-day, I believe, in fully three-fourths of the sewer trenches which are being built every year.

Now, for the remedy, which is more difficult than to call attention to the common faults.

In case of permits to public service corporations, plumbers and abutting owners to cut into the streets, whether paved or unpaved (the former is but little more important than the latter) it is only necessary to stipulate in the permit that "the trenches shall be backfilled by such means as the City Engineer may direct, depending on the character of the excavated material, in such a manner that all excavated material shall be replaced in the trench without raising the grade of the roadway. Flushing will only be permitted in cases where the sub-soil is sand or gravel or other material from which the surplus water will readily drain away."

In criticism of this proposed requirement reference may be made to the volume of the pipe. My reply is that except in trunk sewers (which do not apply to the permits referred to) the volume of the pipe is so little, in comparison to the volume of the trench, as to be insignificant, and it is well known that, in ordinary cases, more earth can be tamped into a trench than is removed from it. There is the familiar farmer's post hole, which will take the earth removed from the hole and the post besides. In my judgment the only case where the rule of "get back all the dirt" cannot apply is in rock excavation, in which case the breaking up of the rock nearly doubles its volume, and the pieces of rock are so large that they cannot be replaced to their original density.

In the case of contract work for sewers, etc., the case is more difficult, in view of the necessary uncertainty of conditions to be met under ground and consequent uncertainty of the most economical way to properly backfill the trench and consequent impracticability of the contractor accurately figuring in advance what the cost per linear foot will be. On this account some contractors are sure to bid far too low to permit proper work, and others figure "safe" with the probability that if they happen to receive the contract the price will be too much advance on the probable cost. In one case the city has the almost impossible task of forcing the contractor to do proper work when the price is too low to permit it without loss. In the other case the probability is that the city will pay too much for the work. An effort should be made to avoid both evils.

My suggestion is, divide prices in such a way that whatever material is encountered a fair price will be allowed the contractor, as follows:

(a) Setting pipes, per linear foot.

(b) Earth excavation, per cubic yard.

(c) Rock excavation, per cubic yard (if rock is likely to be encountered).

(d) Hauling excavated material to spoil bank (if unsuitable for backfilling, and its removal directed by the Engineer), per cubic yard.

(e) Lumber delivered on work (if any required for shoring), per M. B. M.

(f) Placing or replacing (if lumber reused) in sewer trench, per M. B. M.

(g) Refilling trench, if backfilled, by flushing earth excavated from trench, per cubic yard.

(h) Refilling trench, if backfilled, by tamping earth excavated from trench, per cubic yard.

(i) Refilling trench, if backfilled, by flushing suitable borrowed material (to replace unsuitable excavated material, drawn to spoil bank by order of Engineer), including furnishing the material, per cubic yard, measured in the wagons as material is delivered.

(j) Refilling trench, if backfilled, by tamping suitable borrowed material (conditions the same as item "i"), per cubic yard.

(k) Refilling trench with rock excavated from the trench, per cubic yard.

Corresponding with such a schedule of prices in proposal and contract, the specifications should provide as follows:

1. Material excavated from the trench, which, in the opinion of the Engineer, is unsuitable for backfilling, shall be hauled by the contractor to a spoil bank and shall be paid for at the price bid per cubic yard for "hauling excavation to spoil bank." Measurement to be made in the wagons at point where loaded.

2. Flushing in backfilling will be permitted only in case the material is sand or gravel or other material, from which, in the opinion of the engiiner, the surplus water will readily drain away and leave the earth filled solid.

3. Except where flushing is directed by the engiiner, the backfilling shall be done by thorough hand tamping in layers not exceeding 6 in. in depth.

4. Whether backfilling of earth is done by flushing or tamping the full amount of material excavated from the trench, less the volume of the sewer shall be refilled into the trench without raising the grade.

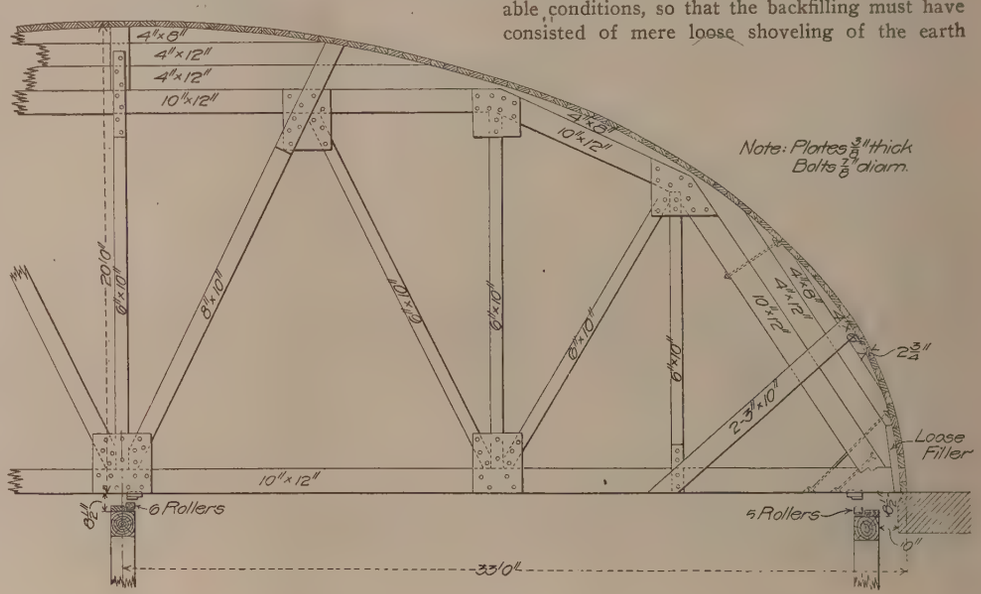
5. In case rock is excavated from the trench it shall be backfilled by carefully hand-placing the excavated rock in layers with succeeding layers of earth well filled into the voids between the pieces of hand-placed rock.

6. In case the excavated material is clay, which, in the opinion of the engiiner, is too wet to enable solid backfilling by tamping, the excavated wet clay and reasonably dry "borrowed" earth shall be tamped into the trench in succeeding layers, using enough of the dry earth to overcome the excess of water in the clay and to provide a solidly filled trench, to the satisfaction of the engineer. The "borrowed" earth, including tamping, to be paid for per cubic yard of "borrowed material," tamped into the trench. Measurement to be made in the wagons as delivered on the work.

If this suggestion is criticised as being complicated the answer is: The conditions are necessarily complicated by practical inability to tell in advance the condition of material to be excavated and consequently the treatment it should receive in backfilling, and the simple but incomplete specifications and method of payment generally adopted in the past have resulted in quite general unsatisfactory results. Some condition should be provided which will correct the evil of poorly filled trenches, however complicated they may be.

Of course, it must be expected that the cost of efficient and proper backfilling of trenches will be much greater than the cost of the inefficient system at present generally in vogue, but the increased cost will be small, in comparison with the saving in repairs to road surfaces and vehicles.

A prominent engineering paper which makes a specialty of earth work in recent times published a series of interesting and complete cost data, evidently collected and tabulated with very great care. One report of twenty-six jobs on sewer sections in one city, aggregating 8,882 lin. ft., shows an average cost of backfilling the trenches of 7.22 cents per cubic yard. The soil is generally reported as good clay, and that backfilling was done by hand shovels. Now, it is well known that this is a very low average cost for the bare shoveling of earth under the most favorable conditions, so that the backfilling must have consisted of mere loose shoveling of the earth into the trench. What of the condition of the roadway, whether paved or unpaved, following this shoddy work, and what of the vehicles which have to pass over this nearly two miles of street during the next several years?



Details of Centering for 175th Street Arch.

An important point not referred to above in connection with repaving over sewer trenches in unpaved streets is the matter of foundation. Even with the greatest care in backfilling the trench, it should be reinforced at the top by a solid Portland cement concrete foundation to the pavement, and the concrete should extend over the edges of the trench about 6 in. on each side.

One engineering journal recently suggested that tamping the earth in backfilling trenches be done with pneumatic or steam rammer, something on the order of pneumatic or steam riveting machines. This offers suggestive food for the mechanical inventor, but, as far as I am aware, nothing of the kind has yet been perfected. For the present tamping must be done by hand, and a good rule is two good men with heavy rammers in the trench to each shoveler outside, and of the three men, put the best two on the tampers. The common practice where there is even a pretence of tamping is, say, four to six shovelers to one tamper, with the poorest man in the trench, because his work doesn't count in the amount of trench backfilled.

The Construction of the 175th Street Arch, New York City.

The Grand Boulevard and Concourse now under construction between 161st St. and Mosholu Parkway, in the Borough of the Bronx, New York City, is carried over 175th St. by an elliptical brick arch, of 66-ft. span and 20-ft. rise, built on a 9 deg. skew. This arch, which was described in detail in The Engineering Record of April 27, 1907, is approached from both directions over an earth fill contained between high, broken range, ashlar faced, rubble backed masonry walls 172 ft. apart, face to face under the coping. The spandrel walls over the arch and abutments are of the same class of masonry as the retaining walls except that the quoins are of Maine granite with 3-in. rock face and 1-in. chisel drafts on all exposed edges. The spandrel walls are 181 ft. 4 in. apart, face to face.

The abutments are of coursed granite backed with rubble, 20 ft. high from the top of the footings to the top of the coping courses or skewbacks which are 12 ft. 6 in. wide. The third course above the footings is a fine cut belt course and those above and below this are rock face, but the courses above have a 1-in. chiselled draft on all edges. The coping course is fine cut granite.

Building First Section of 175th Street Arch.

The arch ring is 40 and 48 in. thick at the crown and springing line, respectively, and is of hardburned brick except the soffit course which is buff vitrified brick. The ring is faced in the planes of the spandrel walls with fine cut granite voussoirs which extend into the ring parallel with the axis of the arch 3 ft. and 4 ft. alternately to bond securely with the brickwork. They are fine cut on the soffit and rock face on the vertical plane with a 1-in. chiselled draft on the radial and a 2-in. draft on all other edges. These voussoirs were cut on the work as required, the form of their soffit faces being laid off on the centering after the latter was in place.

The arch is being constructed in sections beginning at the west end and continuing eastward. The centering is supported on eleven wooden trusses placed in planes perpendicular to the axis of the arch and having the form and dimensions shown in an accompanying illustration. These trusses, which are placed 5 ft. on centers, are supported at their ends and middle points by three lines of 12x12-in. yellow-pine caps carried on 12x12-in. posts 5 ft. on centers resting on timber sills on concrete foundations. The upper and lower chord members of the trusses are of long-leaf yellow pine with the dimensions shown. Owing to the difficulty of securing yellow pine sticks 65 ft. long, the lower chord of each truss is made of two 32½-ft. timbers. The verticals and diagonals are short-leaf yellow pine and the lagging is 2¾x6-in. long-leaf yellow pine plank. Most of the connections are made with ⅜-in. steel plates on both sides of the members and ⅞-in. bolts, arranged as shown in the accompanying sketch. The trusses were built on a level spot near the work and, as it was absolutely necessary to have them all exactly alike so that when the centering was moved forward the lagging over the rear ribs would accurately fit the brickwork built over the front ribs, monuments were placed in the ground by the engineers in charge of the work to show the location of each panel point.

When it is necessary to shift the centering, which weighs about 105 tons, it is moved forward on a system of rollers under each bearing point. While this system is not new, it is believed that the arrangements in this particular case are in some respects superior to any which have been devised before for similar work. To the top of each cap is attached a 3x8-in. yellow pine bearing strip which carries the double oak wedges upon which the trusses rest. At one side of each 3x8-in. bearing plank and attached to the bottom sides of the lower chords of the trusses are 3x8-in. yellow pine roller plates carrying 1x8-in. oak shoes 20 in. long placed 5 ft. on centers. The 4-in. strip on top of each cap not covered by the bearing plate and immediately under the oak shoes is faced with a ¼x4-in. steel plate upon which the rollers bear. The latter are 4-in. sections of extra heavy 3-in. pipe. Five rollers are placed under each shoe at the ends of the trusses and six under each shoe at the middle point. When the centering is in place under the brickwork the clearance between the tops of the rollers and the under surfaces of the shoes is about 2¼ in.

Referring to the sketch it will be seen that it would be impossible for the centering to be lowered with all the lagging in place as the coping stones project slightly beyond the lagging strips immediately above them. To overcome this difficulty the lower ends of the upper chord of each truss were notched to receive filler strips about 4 in. deep and 3 ft. long. When the centering is to be lowered these filler strips are knocked out and the lagging planks supported by them are drawn out by hand.

The trusses were hoisted to place by two guyed derricks with 70-ft. booms, placed one on each side of the roadway near the west approach walls. Fish-plates about 8 ft. long were bolted to each side of the lower chord of each truss to prevent it from buckling while it was hoisted. The wedges were laid on the sills and the trusses placed directly on them so that when the lagging had been laid the centering was ready to carry the first section of brickwork.

The two derricks used in hoisting the trusses handled the facing stones and brick for the first section of the arch from the same position, but when this section had been completed before the centering was moved forward for the second section, they were mounted on top of the section just completed. The second section is now being constructed and when it is finished the derricks and their engines will be moved forward onto it. The earth fill will then be carried over the first section to form a roadway for the convenience of the contractor. These derricks are operated by Lidgerwood hoisting engines supplied with steam by a 40-h.p. boiler placed on the ground a little beyond the east end of the arch.

When the first section of the arch had been finished and the centering was to be moved forward, a bridle of steel cable was attached to the leading truss and a tackle of steel cable was attached to the bridle and to a deadman placed on the center line of the roadway some distance to the eastward. The free line of the tackle was carried to the drum of one of the hoisting engines placed on top of the completed section of the arch. The lagging over the coping stones was removed; the wedges were carefully driven out; and the centering was gradually lowered until the oak shoes took bearing on the rollers. Jackscrews were provided to assist in starting the centering but they were unnecessary as the engine started the load without difficulty. As the centering moved forward the rollers were shifted under each shoe by men who walked from one set of rollers to another on scaffolding hung from the trusses at the proper level. Twelve men were assigned to the work of shifting the rollers, four on each scaffolding; the actual time spent in moving the centering from the time it started till it came to rest was about three hours. The wedges were driven home to lift the centering by jackscrews placed between the ends of the upper wedges in successive sets, two wedges thus being driven at once. When the centering had been adjusted in its new position, with its west end lapping under the finished brickwork about 4 or 5 ft., the surfaces of the lagging and soffit course fitted perfectly. The settlement of the centering under its load has been found to be ¼ in., and the settlement of the arch ring after removal of the centering was ¼ in.

The 175th St. arch was designed and is being constructed under the direction of the engineering department of the Borough of the Bronx, Mr. Josiah A. Briggs, chief engineer, Mr. S. C. Thomson, engineer of highways, and Mr. Chas. Gartensteig, assistant engineer. The Uvalde Asphalt Paving Co. is the contractor. The centering and plan of work was devised by Mr. James H. Small, Jr., and Mr. Wm. Marshall, superintendent for the contractor, under whose personal direction the work has been carried forward since its beginning.

Triangulation and Traverse Work in The Bronx, New York City.

At the present time the City of New York is engaged in making complete topographical maps of all of the five boroughs in pursuance with one of the stipulations of the charter of Greater New York. The charter required that the triangulation system be in conformity with the methods used by the United States Coast and Geodetic Survey, and accordingly the city arranged to have the Survey take charge of the triangulation. In May, 1903, Mr. A. G. Mosman took charge of the triangulation as director, and in July, 1904, the President of the Borough of The Bronx started the field work by erecting the signal stations. An explanation of some of the methods followed in the work was given by Mr. Edward H. Holden, assistant engineer of the Bronx Topographical Bureau, in a paper recently read before the Municipal Engineers of the City of New York, from which these notes are taken.

The work of the Topographical Bureau called for the making of a topographical map on a scale embracing the entire district showing contours, rivers, roads, and such like topography; sectional sheets of the latter map on a larger scale showing more details; traverse sheets with range lines showing the traverse lines and stations with full dimensions; a general map of the entire section showing a plan of streets; sectional maps of the general map on a larger scale, showing contours, street lines, monumented lines with dimensions and grade elevations; and an accurate and complete record of all work done.

The first work was the selection of the triangulation stations. A reconnaissance survey was made showing the inter-visibility of the proposed stations and a plan of the same submitted to Mr. Mosman from which he laid out the base net and the general triangulation scheme. The base line selected was situated at Unionport and accordingly was so named, its length being approximately 1,200 ft.

Sixteen triangulation towers, ranging from 30 to 84 ft. in height were built, which together with eleven buildings and two poles constitute the twenty-nine stations for The Bronx. In the construction of these stations, high poles were used which materially lessened the time and expedited the work. These were set vertically in the vicinity of a proposed station to a height sufficient to get an unobstructed view of the surrounding stations. Without it one must occupy every station to find the inter-visibility of that station and the proposed one. With it you simply climb until you see the desired station and the height of the eye is the height of your station.

The high poles are 6 in. x 6 in. x 96 ft., consisting of 3 in. x 6 in. x 32 ft. timbers bolted together and breaking joints every 16 ft. The pieces are first laid out and marked on the ground, the holes for the bolts are bored and cleats nailed on one side of the pole, 1 ft. apart, on which the observer climbs. The lower section of the pole, consisting of a 6x6-in. section, 32 ft. long, and a half member section extending 16 ft. above the latter is raised by guide ropes, the half member forming the upper part breaking joint with its opposite half. Attached to the top is a pulley block by which the next member is hoisted into place. The poles were each laid out and raised in half a day, the horse used in hauling the lumber also raising the timbers. Five men constitute the necessary force. The poles were guyed all the way up.

Field work under the direction of Mr. Mosman was begun October 22, 1904, and finished in the Fall of 1905. The official report of the final results of the survey was received from Washington, December, 1905. It embodied the geographical positions of all the stations, the azimuths and back azimuths of the lines and the rectangular co-ordinates of the stations. Upon receipt of the report the Typographical Bureau began the work of connecting the traverses with the stations, and in many cases running new traverses connected directly with them. A comparison of the standard length of the Department of Public Works with that of the United States Coast and Geodetic Survey showed a difference of 0.01 ft. in 100 ft., so that in adjusting the traverses to the new survey, the lengths were first corrected for that difference, then started and closed on the triangulation line. The direction of many of the old fixtures laid down and monumented differed from the results of the Coast Survey, and as a result the directions and lengths as fixed by the triangulation in many cases played havoc with the final maps.

In general, traverses connecting the triangulation stations are called primary traverses. They

Forward Tape Stretcher.

are made with the utmost care, every precaution being taken to eliminate errors. The chaining is done in duplicate, the two results not differing more than 0.02 per thousand feet. Cloudy weather is used if possible. The apparatus used for primary traverses are the long tape, mechanical stretchers, and either sticks or tripods for supporting the tape. For secondary traverses the regular city engineers' 50-ft. spring-balance tapes are used with plumb bobs and tacks or marking pins.

The plumb bob, Mr. Holden thinks, has a proper place in the engineer's outfit. All plumb bobs used by the Topographical Bureau are tested to see that the line passing through the center of the chord suspending it shall when produced through the bob pass through the point. This secures the rejection of bobs which are not homogeneous, which are not properly bored to receive the string or have other imperfections. Every time a tape or chain is tested the plumb bobs used with it in the field are tested first.

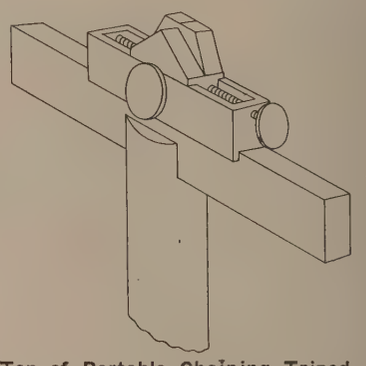
Equal care is taken with the measurement of angles on the traverses, at least two sets of six repetitions being taken and closing the horizon so that the closure shall be within 20 seconds. These limits have been easily maintained with normal conditions and reduce the traverse error to ¼ in. per mile, which is the minimum distance between the triangulation stations.

As an example of the results of the work, the distance between Parkway and Baychester was measured with the primary apparatus, the distance being 6,347.356. The two measurements which were made differed by 0.01 ft. The line was divided into five sections and was defined by monuments set before the measurements were made. The first section was measured three times, and its length being 3,149.8185. The greatest range was 0.0044 ft. As an example of the rate at which the work was done about 2,400 ft. were measured in 45 min., an average of 100 ft. in 2 min.

On Tremont Ave., from Eastern Boulevard to Fort Schuyler Road, 8,000 ft. (over the line and back again) were measured in 5 hours and 55 min., a rate of 100 ft. in 4½ min. Many obstacles presented themselves, much clearing being necessary. The line crossed the salt meadows and the tide being up, the men had to pick their way over and around the streams. It was one of the worst places in The Bronx for this kind of work. The primary traverse apparatus was used.

In another traverse with a total length of 32,000 ft., the error of closure was 0.012 per 1,000 ft., and the six angles gave an angular error of 0.7 seconds per angle.

The line at Eastchester Meadows was measured with a 300-ft. tape, known as hoop-skirt wire tape, having a cross section of 1/50 in. by 3/32 in., and was supported every 50 ft. with a tension of 16 lb. The standardizing of this tape afforded an opportunity for studying the effects of temperature and forms of thermometers necessary with tapes of different cross sections.



Top of Portable Chaining Tripod.

A field comparator was established at Crotona Park and its length determined by the application six times of the Park Department 50-ft. standard length. This was done before sunrise to avoid the effects of the sun. The greatest range in these measurements was 0.003. The 300 ft. was measured twice in the morning and three times after sundown and again measured at an interval of two weeks and found by two measurements to be correct. The probable error of the standardizing was at least one in 600,000. The thermometers used were the chemical thermometers having no backing or support. They were graduated to single degrees, and estimated to ¼ degree. Tests were continued from sunrise on and soon it was made certain that no reliable results could be obtained with the sun shining. Another fact made itself manifest that any kind of thermometer would not answer for all tapes, and also that certain thermometers would not answer at all. The thermometer of the so-called city engineers' tape is housed in a brass tube which stores heat and renders the readings misleading. Anything that stores heat is to be avoided.

The comparator was advantageously located in a place that was fairly shaded during the morning, and the air was influenced by the park, certain breezes causing alternately cool and warm currents of air about the tape. It was thus possible to learn if the tape and thermometers worked together. The tape was first watched and at a noted change the thermometer readings were

simultaneously called for and recorded. This was repeated several times and then the operation was reversed; that is, the thermometers were watched and the tape lengths recorded for the change noted in the thermometers. With the chemical thermometers the corresponding changes tallied exactly. With others this was not the case and their use was discontinued. The cross section of the tape regulates the sensitiveness required in the thermometer.

A most interesting fact has been observed in the 300-ft. tape in that it is constantly increasing in length. The cause, the engineers think, lies in the small cross section for the 16-lb. tension. The greatest care has been taken in reeling and unreeling the tape and no undue strain has been applied to it while so doing. A low-tension does not receive the endorsement of the United States Coast and Geodetic Survey, and the experience of the Topographical Bureau justifies the abandonment of small cross sections and low tensions.

About a year ago some steel tapes were received which had a cross section of 1/50 in. x ¼ in., the outer surface being tinned to prevent rusting. It was found that they did not respond to temperature changes as do the ordinary steel tapes, the explanation being that the surface being bright reflects heat and does not therefore expand the same as the dull steel tape.

The tests made during the Summer of 1906 by the United States Coast and Geodetic Survey with four nickel steel (Invar) tapes show that they give results considerably more accurate and economical than steel tapes. [The tests were described in The Enginering Record of Feb. 9, 1907.] The topographical Bureau in December, 1906, ordered some of these tapes, but they have not yet been delivered. The same types of stretchers and portable supports will be used in connection with them as have been used with the steel tapes.

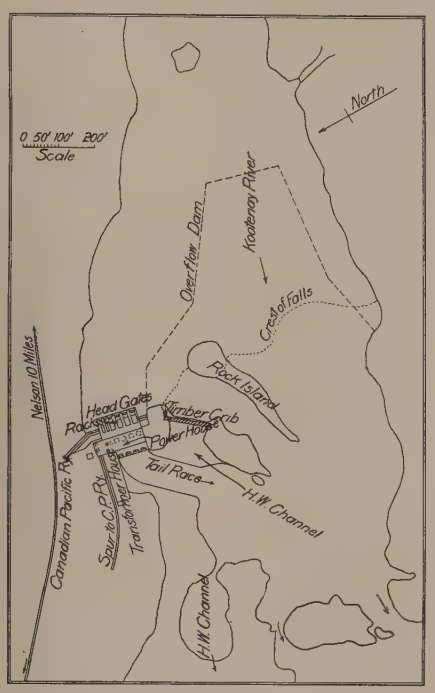
These stretchers and supports were designed by Mr. Holden. The front tape stretcher consists of an unright, hinging sideways at its lower end on its foot base, and terminating at the top in a handle. On this upright, traveling up and down, is a block, carrying the spring balance to regulate the tension. The tension is applied by a revolving half-wheel, centered in the block and working by a lever attached to its diameter. By means of the vertical motion of the block the balance at the front end of the tape is raised and lowered, while the motion on the upright gives lateral adjustment necessary for correct alignment. The rear stretcher is similar to the front one with the exception of the spring balance.

The advantages claimed for this stretcher are that it is manipulated with ease, and is instrumental in producing more accurate work because the tension can be maintained more easily for three minutes than in other forms for three seconds, the tape being absolutely under control for almost any length of time. With the tension released the stretcher is self-supporting, allowing one quickly to protect the tape from inadvertent injury, as from stray animals and from vehicles.

The portable supports are iron tripods with a round bar adjustable in height. The top of the bar terminates in a rectangular cross section forming a T-shape with the bar. This cross arm forms the track on which slides a block which forms a support for the tape, and adjacent to it, at a level with the tape, is the index mark which is brought to coincide with the tape graduations by means of a tangent screw. The block is set approximately near the tape graduation by sliding it along the bar and then clamping it. With the use of these tripods the driving of stakes is avoided, and time saved. Lines can also be measured over parks, lawns and pavements where stakes cannot be driven.

Both the stretchers and the supports are patented and are being put on the market.

The spring balance used with the city engineers' tape is faulty in respects other than that of the thermometer, and it has, in Mr. Holden's opinion, a wrong construction. The level tube is at the handle end, that is farthest away from the tape, working inside of the thermometer tube. The thermometer tube being attached away from the tape, takes a certain inclined position due to the catenary of the tape. This inclination must be secured every time the tape is used. For this position you rely on an inner tube which cannot be fitted close enough to secure parallelism without affecting the tension. The slightest movement out of parallelism gives a wrong level and a wrong length of the tape. Mr. Holden believes that the proper construction should be a reversion of the parts, that is, have the inner tube carrying the level immediately next to the tape with plenty of play between the inner and outer tubes. The level tube being absolutely free from friction would insure accuracy both of the levels and the tension. A further suggestion would be to have the end graduations on the tape and thus do away with the wear of the links which are interposed between the tape and the graduation on the handle.



Plan of Kootenay Power Development.

The Commissary Arrangements adopted by J. G. White & Co. in building railroads in the Philippines have resulted in securing at least 50 per cent. more work for the money paid to native laborers than was obtained on the highway construction in the Visayan Islands. Common labor is paid 50 centavos per day and subsistence. Food had to be provided as part of the wages, for if it was not some of the laborers would have gone hungry in order to use their money for other purposes, a habit observed among some of the negroes tried on the Panama Canal. A study of the subject showed that a diet consisting of six parts of rice, two parts of beef, one each of fish and vegetables, with condiments, was best adapted for natives engaged in hard physical labor. This food is prepared by a Chinese contractor, and while it costs 25 centavos per man daily, it has proved successful in attracting and keeping an excellent grade of men, who remain steadily at work.

The Hydro-Electric Plant of the West Kootenay Power & Light Co., Ltd.

The Upper Bonnington Falls power station of the West Kootenay Power & Light Co., Ltd., is located on the Kootenay River in British Columbia, 10 miles from Nelson, a town on the west arm of Kootenay Lake. The Kootenay River rises in British Columbia, a short distance east of the head waters of the Columbia River and flows southerly, approximately parallel to the north flowing waters of the Columbia for fifty miles and then crosses the international boundary into the United States. Here it continues to flow south then turns northwest and enters Canadian territory again, soon expanding into what is known as Kootenay Lake. The length of the river in the United States is about 120 miles. Kootenay Lake, which receives a small number of streams in its northern arm, discharges by way of the west arm, the river from this point keeping a southwesterly course to its junction with the Columbia River at Robson. The total length of the river is about 350 miles and the area drained by it and its tributaries above the power house site is about 9,800 sq. mi., of which 2,500 sq. mi. are in United States territory.

The development here described is owned by the company which has already developed the lower falls. The site of the plant was chosen on the north bank of the river, the channel between Rocky Island and that bank being used for the approach and the tailrace. The power house is built in the river and during its construction a cofferdam was built from the bank to the island, thus unwatering the whole site and diverting the flow to the south of the island. The installation is planned for 32,000 h.p., with a working head of 70 ft.

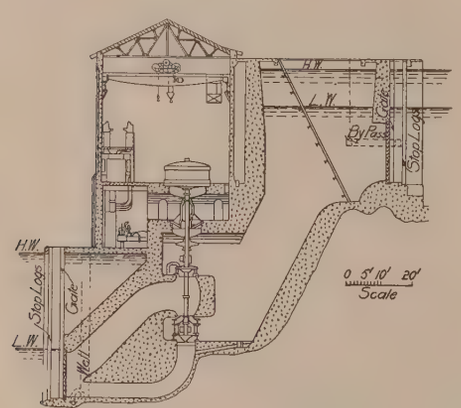
The minimum flow of the river was found to be 5,850 cu. ft. per second, the minimum occurring in January, 1905. The variations in the flow are very great, but no measurement of the maximum has been made as far as is known. The periods of high and low water differ from those of rivers not situated in mountainous country, and in the case of the Kootenay River, which depends largely for its supply on the melting snow on the mountains, the high water is comparatively late, in June and July. The variations between high and low water above and below the falls do not correspond, because the channel of the river below the falls is constricted by a number of rocky islands. These impede the flow of the stream, and it is intended to remove them in part so as to more nearly equalize the rise and fall on either side of the power station. Owing to these variations, which can never be entirely eliminated, except at a cost beyond commercial practicability, the vertical type of turbine was adopted, using all the head available at all stages of water, instead of adopting a head which would be nearly constant and which would involve a sacrifice of a large amount of power when low water prevailed. When the natural head is least, the volume of water used is not important, as the quantity available is more than ample, but at periods of low water the head is greatest and the vertical setting is an advantage since it permits the use of a higher head. Had a horizontal wheel been adopted, it would have been necessary to set the power house floor above high water, and, allowing the use of a draft tube of 24 ft., at this altitude, to maintain the tail water above low water, which would have involved a loss of head for a considerable period of each year, when water is low and consequently when head is most valuable.

It is the intention to increase the natural head by building a timber dam across the river to a height that will drown the rapids above the fall, thus affording an increase of head of 10 ft. It is

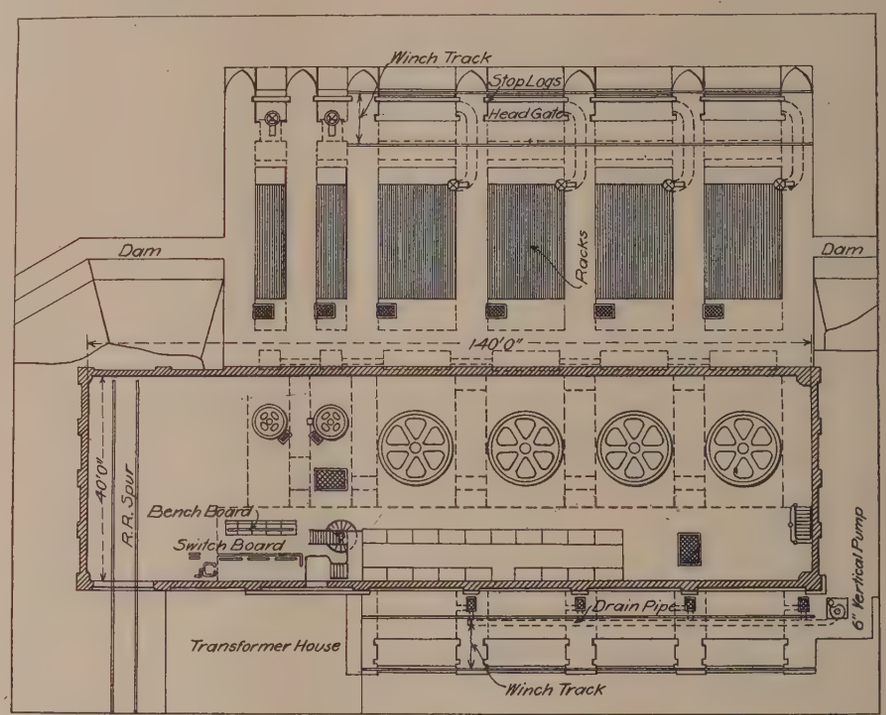
possible to construct work at the outlet of Kootenay Lake to maintain the lake level more nearly uniform and thus assist materially in reducing maximum discharge and increasing minimum discharge in the river. This will make the working conditions much better and increase the potentiality of the river considerably. The matter will be brought to the attention of the Government, for in addition to improving the power conditions of the river, it will afford a great advantage to navigation in the lake, which is now and will perhaps always be a part of the transportation system of this district, owing to the great difficulty of constructing a railway from Kootenay Landing to Proctor, 17 miles above Nelson.

The power house, measuring 40 x 140 ft., is built across the north channel of the river, and from the end of it the timber overflow dam continues to the south bank. Despite the material assistance of the natural channel, about 40,000 cu. yd. of rock had to be removed for the power house foundations and the tail race. The removal of this rock was somewhat difficult owing to the confined area in which the work had to be done, the difficulty of disposing of it, the nature of the rock, Nelson granite, and the irregularity in the direction of the seams. Some of the rock had to be excavated under water. As a large part of the concrete work admitted of the use of large stones, those most suitable for the work were piled up in convenient places, and a considerable quantity of the remainder were passed through crushers, and the stone used in the concrete.

The power house building is entirely of monolithic concrete construction reinforced wherever necessary; the reinforcement consisting of round steel rods and in some places of steel rails, which were used in parts of the structure under severe strain. The four water wheels are placed in a row side by side and to the north of them are the two exciters. The switchboards are located on the down-stream side of the power house and beneath them runs a chamber in which the pressure pumps, governors and low tension tables are located. The only machinery on the floor are the generators, controlling board and the low tension switches. A spur railroad track connecting with the Canadian Pacific is run into the north end of the building so that the crane can lift machinery directly from the cars.



Section through Main Unit.



Plan of Power House.

The water enters the intake through the submerged openings between the piers, and can be shut off by both gates and stop logs, the latter being provided so as to render the gates accessible in case of emergency. Behind the gates are the screens which are rendered accessible for repairs or cleaning. The intake and draft tubes and the turbine chamber are formed entirely of concrete, built integral with the structure, as cored openings in the monolith. Care was taken to secure very smooth surfaces on the inside of all passages, and their curves and cross sections were designed to offer as little resistance to the water as practicable. The exciter turbines are arranged similar to the main units but operate under a constant head by having the discharge at a higher head, which level is obtained by a weir. The tailrace openings are also provided with gates and stop logs, and any chamber can be emptied by a system of drains and valves, which lead the water to a well at the south end of the building, where a centrifugal pump throws it out into the tailrace. In laying out the station facility for inspection and the making of repairs were kept prominently in mind.

The floor of the power house is 24½ ft. below low water and 36½ ft. below high water, and since the building is located in the channel of the river and acts as a dam, special provision had to be made to care for whatever leakage should occur through the upstream wall of the building. The problem was solved by making the wall double as shown in the accompanying cross section and arranging for the drainage of the air space thus created.

Each main unit operates at a speed of 180 r.p.m. under a head of 70 ft., and can deliver 8,000 mechanical horse power to its electrical generator. Each unit will require 1,260 cu. ft. per second, a volume equal to the flow of the river 100 ft. wide, 5 ft. deep, moving with a velocity of 151.2 ft. per minute. Each turbine consists of three inward flow Francis runners mounted on a vertical shaft, each runner being equipped with its own distributor and movable guide vanes. The top runner discharges downward and the middle runner upward into the same draft tube, and the bottom runner downward into a separate draft tube, which joins the former one just in front of the tailrace gates. The distributors are bolted to heavy cast-iron base rings secured to the concrete masonry, which forms the turbine wheel casings and the draft tubes for carrying the discharge water to the tailrace.

The runners are made of special turbine metal, approximately 88 parts copper, 10 parts tin and 2 parts zinc. Each is built in one piece, cast in cores and bolted to the hub. The hubs are formed by enlarging the shaft at the points where the runners are attached, heavy flanges being turned on the shaft above the hubs, for attaching the runners.

In order to render the total resultant thrust on the shaft as small as possible, the chamber above the upper runner is by-passed to the draft tube, which relieves the pressure in the chamber, and thus eliminates the hydraulic thrust of this runner. Since the two other runners discharge in opposite directions, the total resultant thrust is theoretically zero. The thrust bearing, however, is designed to take care of a generous amount of thrust over and above the dead weights of the revolving parts. The latter consist of the rotor of the generator, the shaft, in three sections, three runners weighing 4,000 lb. each, couplings and bolts, making a total of 170,000 lb.

The thrust bearing consists of two specially close grained cast-iron discs. The lower disc is supported by a ball seat, while the upper is securely held in place by an adjusting nut upon the shaft. The discs have raised flanges on the outside and inside circumferences so as to form an annular pressure chamber into which the oil is forced under a pressure of 250 lb., thus lifting the revolving parts. When these parts are lifted the oil escapes between the surfaces of the discs, supporting the total weight on a film of oil.

The thrust bearing is fitted with a cover with glass peep holes. The oil is supplied to the bearing from a high pressure triplex pump, capable of working under a pressure of 500 lb. per square inch, and driven from the main turbine shaft, by bevel gearing and countershafting. Each turbine has its own pump, oil tank, piping, gauges, etc., making it independent and complete in itself. An extra motor-driven pump has been provided to act as a spare for any one of the main units or exciters and to supply oil to the turbines when starting up.

The main turbine shaft is kept in alignment by three guide bearings, the upper guide bearing being built in conjunction with the thrust bearing. It is lined with Parson's White Brass and is lubricated by oil provided under pressure. The intermediate and lower guide bearings, the former situated above the upper runner, and the latter between the intermediate and lower runners are of lignum vitae, made by driving the wood into dove-tail spaces in bronze boxes. As these bearings are submerged, they are well lubricated with water and require little or no attention.

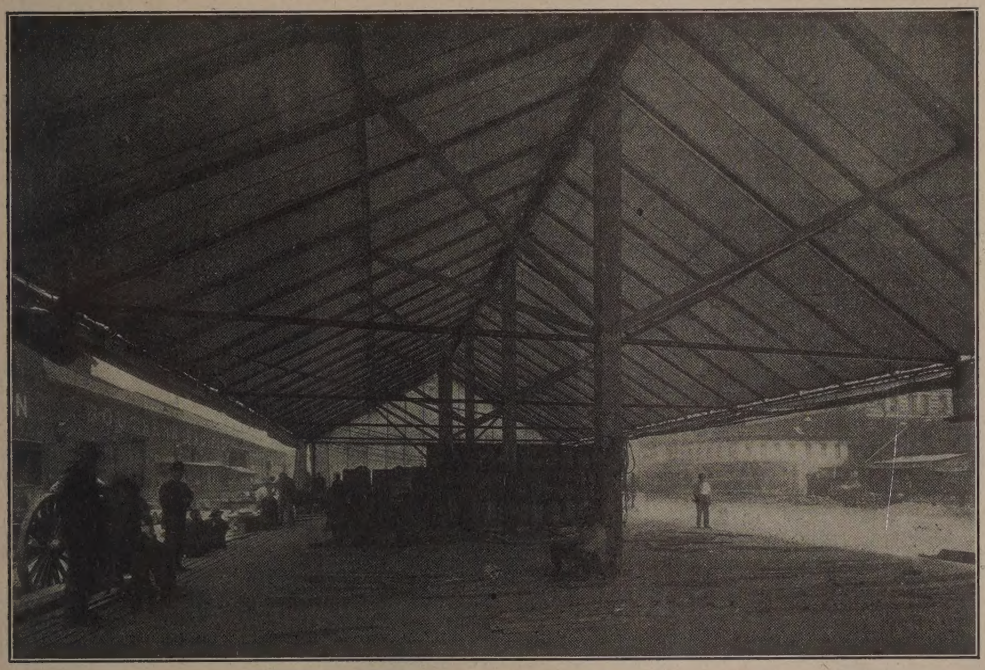
The water is distributed to the runners through malleable iron, movable guide vanes, operated by means of links, which are connected to the vane

operating ring. The latter is operated by rods and levers from a vertical shaft which leads to the operating deck, where the governor is located. The governors are furnished with remote electrical control.

The two upper sections of the main turbine shaft are joined together by a cast steel coupling 4 ft. in diameter. The brake mechanism is fitted about the coupling, the outer edges forming the braking surface, against which the two shoes are applied, hand mechanism being provided to bring a force of 10,000 lb. on each shoe.

The turbines are guaranteed to give an efficiency of 80 per cent. when delivering 8,000 h.p. The hydraulic machinery was all designed and built by the I. P. Morris Co., of which Mr. W. M. White is the hydraulic engineer.

The generators each have a capacity of 4,500 kw. at 2,200 volts and 80 per cent. power factor, at a frequency of 60 cycles. They are of the umbrella type and directly connected to the water wheels. At the present time only two of the units have been installed. The exciters are two in number, each of a capacity sufficient to excite the entire equipment when finally installed. They are also of the umbrella type and directly connected to vertical wheels.



Umbrella Shed with Roof Frame Covered with Canvas.

The current from the generators is carried to bus bars in compartments elevated above the station floor, and formed entirely of concrete. The top of the bus bar compartment, in which all the operating transformers are placed, forms the base of a platform on which are mounted nineteen 2,200 volt oil switches, all of which are motor operated by distant control from the benchboard. The latter which contains the control for the whole station, including switches for the 2,200, 22,000 and 60,000-volt switches, together with the speeders for the water wheels, is situated in front of the instrument panel at the end of the station, all connections thereto being reduced to a pressure of 110 volts. The general switching arrangement has been worked out on the basis of two separate and distinct plants, which may be coupled together or run separately on any transmission line or any bank of transformers.

The cables for connecting to the low voltage bus bars, and from them to the transformer station adjacent, are all rubber covered and drawn into bituminous fibre ducts, which are embedded in the concrete floors and partitions.

The transformer house, located at right angles to the power house and at the north end of the latter, is 36 ft. 1 in. wide, 136 ft. 6½ in. long, divided longitudinally into two sections, running the entire length of the building. The southern of these two divisions is devoted to the switches and lightning arrestors and is built in two stories. The north section is divided into five separate compartments, each of which contains three transformers, the barriers between the transformer banks and also the wall forming the main division of the building being of concrete.

The floor of the transformer room is 4 ft. 5½ in. above the top of rail of the Canadian Pacific spur, which runs along the north wall of the building. The latter consists of a series of doors, and the transformers being mounted on trucks, can be run from their positions directly onto flat cars with great ease.

Practically all of the power is transmitted at 60,000 volts, though the town of Rossland is supplied with 22,000 volt current over the existing lines of the old plant. The longest transmission at present is 83 miles, to Greenwood. All of the power so far sold is used in mining for large motor equipments and for the lighting and power of mines and mining towns within a radius of about 83 miles. It is expected that the company will at some future date sell power to the railways in the vicinity of Rossland for operating over the heavy grades. The haulage over these grades at the present time is done by steam locomotives of special type, some of them being geared. Switchbacks are necessary at a number of points. The heaviest grade is about 4½ per cent.

The plant was designed by Messrs. Ross & Holgate of Montreal, Canada, from whose paper before the Canadian Society of Civil Engineers, the data for this article were obtained.

The Cast-Iron Bridge erected by the Coalbrookdale foundry in 1797 at Stanford, Worcestershire, England, from the plans of John Nash, has been replaced by a Hennebique reinforced concrete structure of 96⅔ ft. span. It has three arched ribs; the center one is 20 in. wide at the springing line and 30 in. deep, and 20x22 in. at the crown, where the effective depth is increased 7 in. by the deck slab. The outer ribs are 14x30 in. and 14x22 in. at the springing and crown respectively. They are connected by transverse walls which are carried up to support the deck. Details of the old and new structures are given in "Engineering" of August 23.

An Umbrella Shed for Market Storage.

A 43x100-ft. umbrella shed has recently been built in front of pier 36 North River, New York, on part of an area secured by moving the bulkhead line out about 50 ft. farther into the river. It is used largely for temporary storage, especially of produce for city markets which is handled almost daily. In order to facilitate trucking and freight handling it was considered necessary to avoid to the utmost obstruction by columns along the sides, and the structure was designed with a light roof carried entirely by a single center longitudinal line of vertical columns 20 ft. apart on centers. The area covered by the shed was paved with asphalt pavement, in which six 4x4-in. pits were excavated to a depth of about 5 ft., and filled with concrete. Before they were concreted, 10x10-in. vertical posts 25 ft. long with 10x10-in. horizontal transverse sills 6 ft. long bolted to their lower ends were set in them and thoroughly bedded in the concrete. These posts were carefully plumbed and served to carry the entire superstructure. At their upper ends they are connected by a 3x10-in. mortised ribbed purlin and support the trussed rafters.

Each truss is a triangular framework of 2½-in. screwed steel pipe, 2½ in. in diameter for the top chord and 3 in. in diameter for the bottom chord. The truss has a depth of 8 ft., and each side of the top chord, or each rafter, is a single length of pipe fitted at the upper end with an oblique screwed flange. The flanges of the two connected chord pieces are bolted together through the top of the post. The lower end of the top chord is screwed into a casting into which there is also screwed the end of the bottom chord pipe, which at the opposite end is also flange-connected to the vertical post through which it is bolted. The castings at the ends of the bottom chords also receive the screwed ends of horizontal eaves struts of 2½-in. pipe which support the intermediate rafters of 2x6-in. timbers 4 ft. apart with loop connection of flat iron engaging the struts. The upper ends of these rafters are mortised in the usual way into the ridge purlin. Half way between the ridge and eaves purlin there is a 2x6-in. intermediate purlin supported by a bent strap engaging the top chord of the roof truss.

The framework thus provided is covered with a continuous sheet of paraffined heavy canvas with transverse breadths sewed together sail fashion to make one large sheet or tarpaulin 100 ft. long and about 50 ft. wide, reaching continuously from the eaves on one side, up over the ridge purlin and down to the eaves on the other side where it is laced to the eaves strut. The side walls are formed of vertical curtains of the same material mounted on rollers at the eaves strut, which may be rolled up and give an entirely clear opening under the roof, or may be lowered and enclose the space to protect the goods within from rain or snow.

As the structure is very light and may be exposed to severe wind, extra bracing is provided by four inclined 4x5-in. struts, radiating from the intersection of the vertical post and its lower chord to the intermediate purlin, where they are kneebraced to secure stiffness and transmit the possible stresses to the main rafters. Additional stability is secured for the vertical posts by bolting to opposite sides of them pairs of 6x6-in. timbers 40 ft. long laid on top of the original asphalt pavements and serving as joists for the wooden floors, which is intermediately supported by 2x6-in. transverse joists also laid upon the pavement about 2 ft. apart.

Care is taken to leave 1-in. cracks between the outside longitudinal floor planks to provide for drainage. This construction is very simple and

proved easy to build and satisfactory in service. The estimated cost, including roof covering, end and side walls and floor, is only about $2,500, which compares very favorably with the cost of any other type of structure of equal strength and durability having the same cubical contents. It was erected in about two weeks actual working time by a small force of carpenters and pipe fitters. It was built for the Clyde Steamship Line by John Monk & Sons, contractors; Mr. J. W. Ripley, chief engineer, structural department.

Court Decision on Overflow of Land.

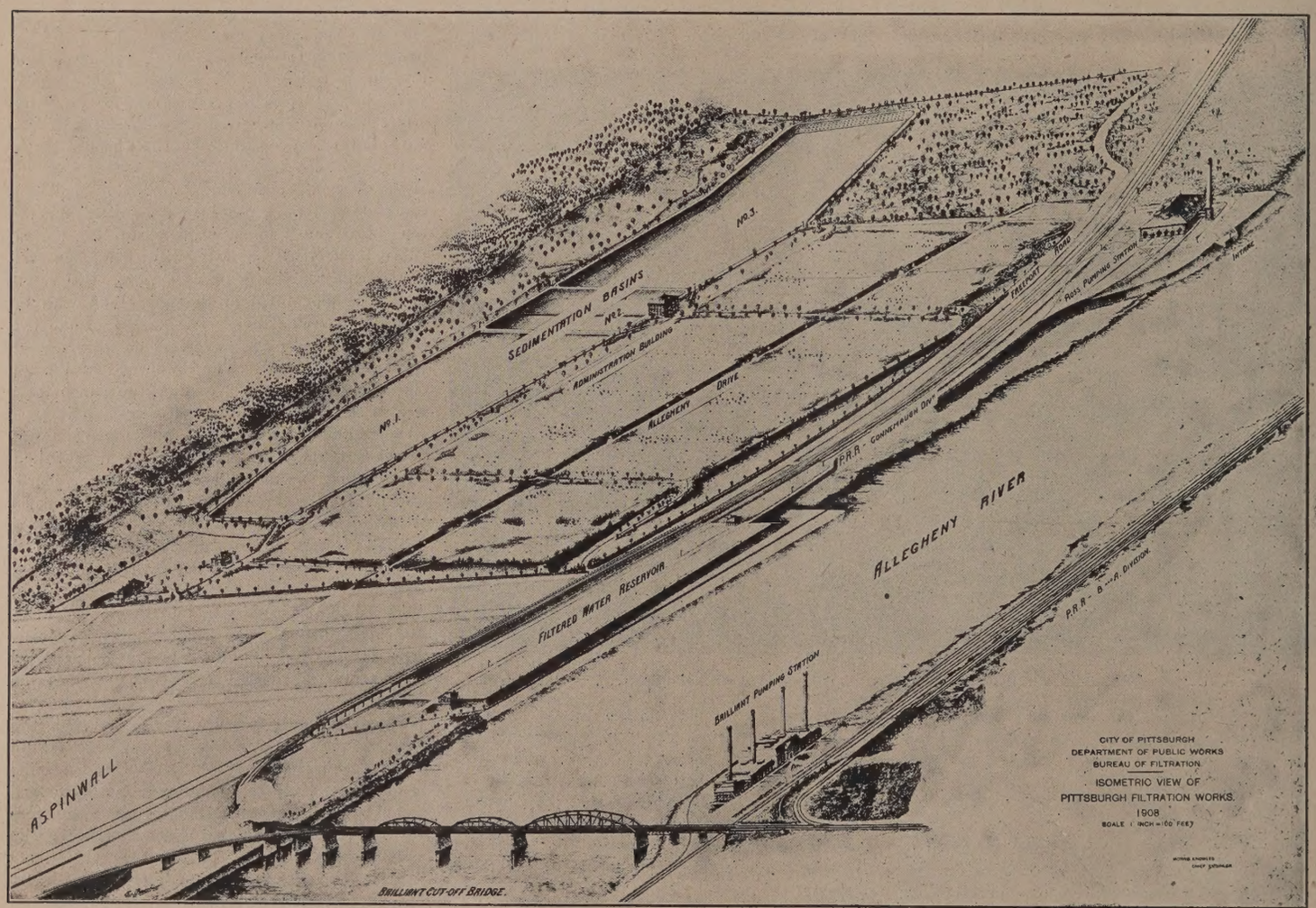
The overflow of land below a dam by the discharge of impounded water was recent'y before the Maine Supreme Court in Barker v. French, 67 Atl. Rep., 308. The laws of that State, unlike those of Massachusetts, do not authorize a complaint for overflowing lands below a dam, and consequently a case of this nature is necessarily an action at common law. Under this law, the court rules, a mill owner can only maintain a head of water for the use of his mill and only let it out at such times and in such quantities as are proper and reasonable for the use of his mill. He cannot hold water back when he has no use for it and there is no need of it. And if he has occasion to use his mill, he cannot turn out more water than is reasonably necessary and proper for the reasonable use of his mill. He must so far have regard for the rights and interests of those below him, although, within his rights to operate his mill, he can exercise these privileges, and if those below are injured, it is their misfortune in owning land below the mill. The case practically depends upon what constitutes reasonable use of water for power purposes.

The Pittsburg Filtration Works.

The design and construction of the water purification plant now being built at Pittsburg under the direction of Mr. Morris Knowles, was the subject of a series of articles printed in this journal during December of last year. The plant is of such an enormous size that those unacquainted with the details of filteration works will probably appreciate its magnitude better from the accompanying reproduction of a bird's-eye view of the plant as it will appear when completed, than from the more elaborate details of the design, which have already been published. It is located on the Allegheny River, from which the raw water is drawn, and considerable pains will be taken in the final finishing of the plant to give it an attractive appearance. The general idea that has been followed in developing the landscape plant has been to isolate the site from the surroundings by hedges and to plant hardy shrubs and trees of slow growth, which will require pruning only at considerable intervals. All attempts at elaborate decorations, such as flower gardens, set plants and fountains, have been avoided and the money will be spent on more permanent work. A growth of heavy timber on the hill back of the site will be retained. The entrances to the filter galleries from the drive over the Allegheny water main will be relieved by shrubbery. The entrances to the plant will be closed by iron gates carried by large stone piers. All overhead wires have been avoided by a system of underground ducts in which wires for all purposes will be carried.

The water is taken through an intake from the river into the low-lift Ross pumping station shown in the upper right-hand portion of the engraving. The pumps deliver it to the central sedimentation basin, marked No. 2 in the engraving. This has a capacity of 20,000,000 gal. and is flanked on either side by two much larger sedimentation basins, the three having a total capacity of about 150,000,000 gal. The water will pass from them to the filters, which are covered and lie on either side of Allegheny Drive, along which runs the Allegheny city water main. The filtered water flows into a covered reservoir built along the bank of the river, from which it passes through parallel twin steel conduits to the Brilliant pumping station of the Pittsburg waterworks. The plant will have a net capacity of approximately 100,000,000 gal. of water per day under normal operating conditions, with a maximum rate of 3,000,000 gal. per acre per day.

The filter beds are 46 in number, each with a net filtering area of 1 acre. Beds are arranged in eight rows transverse to the Allegheny Drive, with a covered pipe gallery 31 ft. wide in the clear between each alternate row of filters, or four galleries in all. These galleries are approximately 1,000 ft. long with the exception of the one at the end, and are divided in half transversely by the roadway over the 60-in. rising main of the Allegheny water works. The filters are entered from the galleries and all sand washing will be done in them, special appliances having been built to handle the sand economically between the filters and the washing apparatus. No storage for dirty sand is provided, for the system of operations will involve the continuous removal, washing and restoration of the sand. Provision has been made for warming these galleries so that all work connected with the maintenance of the plant can be done without interruption from the cold.

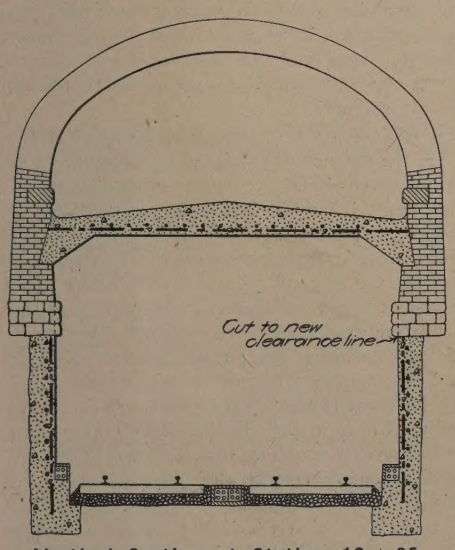


Isometric View of the Pittsburgh Water Purification Works Now Approaching Completion.

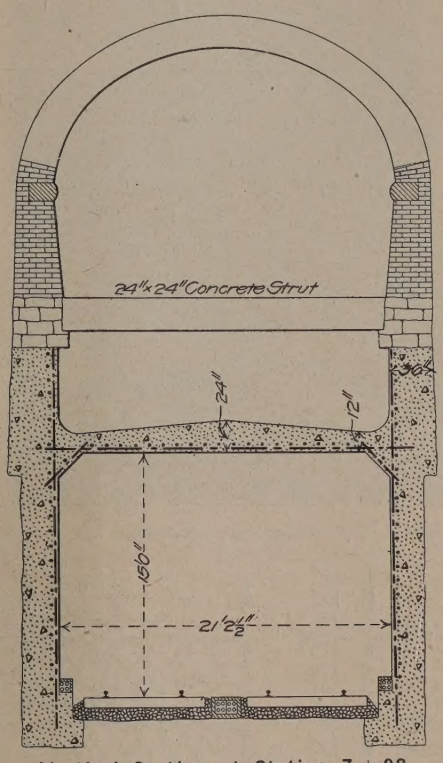
The Reconstruction of the Eighth Street Tunnel, Kansas City.

Upon the reorganization of the Metropolitan Street Railway Co. of Kansas City, Mo., in 1902 it was decided to secure better street car facilities between the Union Depot and the heart of the city. The depot is located in what is known as the "West Bottoms," of the Kaw River, at the foot of the bluff on the Missouri side. A number of street car lines reached the bottom lands, one of them the 12th St. cable line passing over a light viaduct on a 12 per cent. grade and another, the 9th St. cable line, being on a 27 per cent. grade.

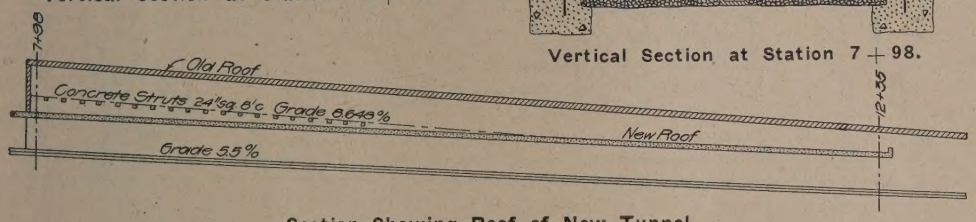
It was finally determined to make the improvements in the 8th St. tunnel which ran into the bluff close to the depot on an 8.648 per cent. grade. By this route the center of the city can be reached in about 8 min. The new schedule which was proposed called for two cars on each track in the tunnel at all busy hours, a condition too dangerous to be attempted on such a grade. The 8th St. line is the most direct between Kansas City, Mo., and Kansas City, Kan., and in the former city runs on the surface to Washington St., thence by the tunnel through the bluff directly onto the elevated structure, at a point about 500 ft. from the Union Depot, and continuing elevated to Kansas City, Kan. The plans for rebuilding called for changing the grade in the tunnel and strengthening and rebuilding the elevated to the depot, to accommodate the 80,000-lb. cars and thus make the line the main carrier to the different points in the cities, and building a return loop on the elevated at the passenger station.



Vertical Section at Station 12 + 35.



Vertical Section at Station 7 + 98.



Section Showing Roof of New Tunnel.

The tunnel is in a thickly settled portion of the city and above its center line were a street lined with residences, a church and one house. The old tunnel was a 3-center brick arch, with 26-in. arch rings and 21 ft. 2½-in. span, the side walls battering below the springing line. Its length was 786.4 ft. The material in the bluff varied in character, limestone and a slippery shale being predominate. The shale was of a character to afford a good foundation and in general was a good material if protected from air and frost.

A study of all the conditions resulted in the selection of a reinforced concrete rectangular section for the tunnel, and a grade of 5.5 per cent., starting from the old elevated at the west end. The slope had to be extended 543 ft. beyond the old one to Broadway. This required the construction of 220 ft. of open cut retaining walls, 323 ft. of cut and cover section, including a 33-ft. arch and station at Washington St., and a new roof and side walls wherever necessary under the old tunnel. To provide for the new approach the street was widened for 20 ft. on each side for one block.

The flood of June 1, 1903, carried away considerable of the elevated structure, and the tunnel work was to be carried on in connection with its reconstruction so that the entire line could be opened at the same time. The work was commenced in the latter part of August, 1903, the open cut work being the first part started. The first move in the latter work was to drive piling outside the proposed excavation, to be used later to hold the sheeting The excavation east of Washington St. was handled entirely with wagons, and that portion of the open cut west of Washington St., and the tunnel itself was done with the aid of cars let down the grade on a 24-in. track by gravity and hauled back by a hoisting engine. This engine was installed at Washington St., and gradually lowered as the work progressed, being removed from the tunnel only when forced out by the track laying gang. All the excavated material west of Washington St. was wasted at the face of the bluff for the use of the park commission.

At the upper end the roof of the new tunnel structure was below the floor of the old one, but going down the new roof gradually cut into the old tunnel. This not only required a special design, but a careful method of procedure which would assure the safety of the older structure. The excavation under the old arch was handled by sinking a 12-ft. and in part a 13-ft. ditch the entire length down the sub-grade, and then gradually trimming the sides until only a 3-ft. or 4-ft. shoulder was left supporting the old footings. This shoulder support for the walls was divided into alternate 10-ft. and 12-ft. sections and excavation continued in the latter, going back 24 in. under the old wall and 18 in. below the new sub-grade. These sections were filled with reinforced concrete and allowed to set for 10 or 14 days, before the adjacent sections were excavated.

The shale and lime stone were found in nearly horizontal strata. A Fisher direct-connected gasoline air compressor and two air drills were installed and in addition to their work considerable drilling was done by hand with churn drills. After the first ditch was cut the use of the air drills was practically abandoned on account of the greater ease of placing a hole by hand in a difficult position. All of the holes were shallow and the shots light, the heaviest charge being 2½ sticks of 40 per cent. dynamite in a 4-ft. hole. For drilling into the shale an ordinary 1½-in. bridge auger, with the worm filed off, was used.

No trouble was experienced except at the east end of the old tunnel, where the excavation was deepest. Here the shale had vertical seams, and as it had been exposed to the air and frost for years, it was dried up into small cubes with almost no adhesion. The treacherous nature of the shale and the unevenness of the pile driving caused much more bracing to be used than would have been otherwise necessary. Upon this bracing the runways for the concrete barrows were afterwards placed. The braces were box struts of 2x8-in. stuff spiked together, and carried a house jack in one end. A test made of one of these struts resulted in breaking the jack without injury to the strut. Only one cave-in occurred, and that was outside of the old tunnel at the site of what was formerly a ravine.

The new tunnel has a flat roof of 21 ft. 2½ in. span, reinforced with 1¼ in. Johnson corrugated bars, 4 in. center to center across the span, and ¾-in. bars 12 in. center to center longitudinally, with 24-in. of concrete in the center and 13 in. at the haunches. The roof is carried on the side walls with the aid of an 18-in. 45-deg. continuous bracket. This roof extended 300 ft. into the old tunnel and was designed to act as a strut for the old side walls. Whenever no new side walls were built a groove was cut into the old brick walls and dowel pins put in before the roof was concreted. At the mouth of the old tunnel 24x24-in. concrete struts, 8 ft. center to center were put in between the foundations of the old walls. The height of the new tunnel above the top of the rail is 15 ft.

At the east end where the excavation was deepest and consequently the risk greatest, a complete 10-ft. section of the new side walls and roof was completed and allowed to set before undermining adjacent sections. The excavation for this section was made 12 ft. long and all longitudinal rods were cut in 12-ft. lengths, allowing 1 ft. to project through the forms to bond on to the next section.

At Washington St. a station was located and in order to provide the necessary platforms, the cross section was changed to a 33-ft. 3-center arch reinforced with two rows of ⅞-in. bent bars, 7 and 9 in. respectively center to center and ¾-in. longitudinal rods 12 in. center to center, the arch ring being 15 in. thick at the crown. The concreting of this arch was brought up to the springing line and allowed to set and the balance carried on continuously until the entire arch was completed.

East of the Washington St. station a poor foundation was encountered and reinforced concrete beams were placed below the sub-grade from one foundation to the other forming a sort of gridiron. This was done for about 60 ft., and then an old fill was encountered in which it was

almost impossible to get any foundation at all. It was, therefore, decided to make a complete concrete tube and a solid 18-in. floor was laid, reinforced with old railroad iron every 12 in., this floor being necessary for about 200 ft. For the side walls of the open-cut approach 18-in. walls surmounted by a slightly ornamented coping were built.

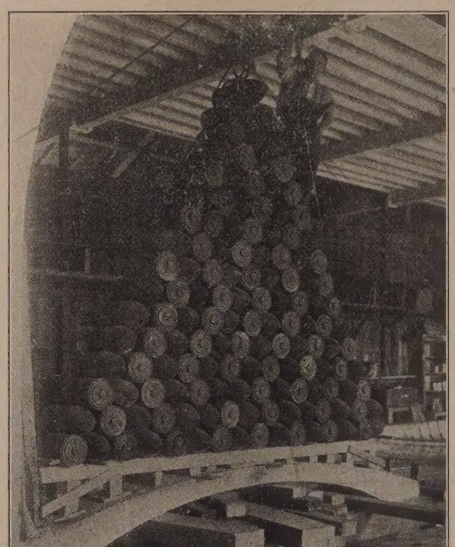
The concrete used throughout was a 1:3:5 mixture with Lehigh and Atlas Portland cement, Missouri River sand and ¾-in. limestone. A No. 2 Smith mixer was used, and as high as 125 cu. yd. in 10 hr. was wheeled to the forms, 100 yd. being the usual day's work. Two inch planks were used exclusively for the concrete forms. The concrete was mixed on the surface for all parts of the work and run by means of wheelbarrows and spouts into place by gravity. Whenever possible the concrete under the old tunnel was wheeled in and dumped from the roof for the side walls. In other places it was dumped into a car and run down to the forms and shovelled into place, both sides being filled at once and kept at the same level. No attempt was made to get an exceptionally fine finish on the walls, as speed of construction consistent with strength and safety was the great object. Although the excavation was pushed both day and night, concrete work was carried on only during the day. The new tunnel was opened for traffic on April 14, 1904, 7 months and 14 days from the commencement of the work.

The work was done for the Metropolitan Street Railway Co., of Kansas City, under the supervision of Ford, Bacon & Davis, New York, Mr. C. M. Black being the engineer in charge of the Kansas City office. The contractors for the job were the General Construction Co., of Kansas City, under Mr. R. W. Waddell, the general manager. The contract was for the lump sum of $150,000. The work was described by Mr. W. M. Archibald in a paper before the Engineering Association of the South, from which the data for this article were taken.

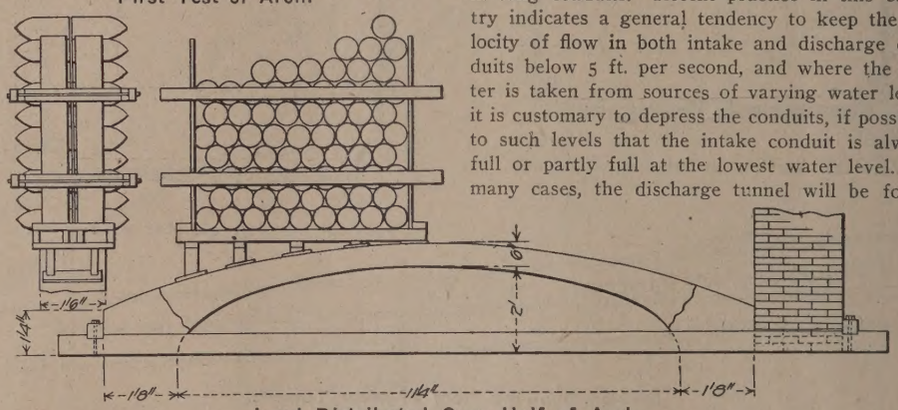
Book Notes.

Considerable attention has been attracted to a series of articles on "Switches and Turnouts" contributed to the "Journal of the Worcester Polytechnic Institute" this year. The author, Professor Howard Chapin Ives, has developed the subject in a logical manner which should be particularly useful in the class-room. Special care has been devoted to the descriptions of the different forms of switches and to their effect on the lead; to the statement of practical conclusions at various places in the text and to the design of the slip switch, the mathematics of which have rarely been discussed. These papers have been reprinted by Mr. J. P. Williams, Worcester Polytechnic Institute, Worcester, Mass., who is selling them for 50 cents. As an explanation of the theory of switches and turnouts the pamphlet leaves nothing to be desired, and those engineers who are familiar only with the method used on one railroad system, and the tables for that method, will probably find the comprehensive discussion of the subject by Professor Ives an interesting and valuable review.

The fundamental factor in hydraulic power development, water supply and some other engineering works is the amount of available water. Although the importance of this factor is self-evident, it has long been a matter of surprise that so little information concerning the methods of gauging the flow of water is readily available. Most textbooks on hydraulics and surveying devote a few papes to these considerations, but the treatment is necessarily very sketchy. For this reason a small book on "River Discharge," recently written by Messrs. John C. Hoyt and Nathan C. Grover, is likely to find a wide circle of appreciative readers. There are few things offering a bigger chance of reward to the engineer who keeps his eyes open than the small undeveloped water powers throughout the country. Before their value can be properly determined, however, it is necessary to make a series of stream gaugings and to determine the amount of pondage that can be provided readily. Probably there is no other book which furnishes so much information on hydrographic work of this sort as this volume by two of the leading members of the engineering staff of the United States Geological Survey. It explains the conditions affecting stream flow, describes the methods, instruments and equipments used in making gaugings, outlines the best practice in selecting stations for making such measurements, describes the construction of weir stations, and gives a full discussion of the methods of analyzing and using the data accumulated in this manner. The book is to be highly recommended from both theoretical and practical points of view. (New York, John Wiley & Sons; $2.00.)



First Test of Arch.



Load Distributed Over Half of Arch.

Letters to the Editor.

Test of Arch for Filter.

Sir: With the idea that the result may interest your readers, there is sent you herewith a print showing the details of a recent test of a concrete arch. A timber framework made the abutments of the arch practically unyielding.

The first test is shown in the accompanying photograph, the load being 1,464 lb. per square foot. In the second test, the load was confined to about half of the arch, 9 square feet. The load over this portion of the arch was nearly uniform and aggregated 2,847 lb. per square foot; the arch cracked at the haunches. The shock or jar incident to this cracking was sufficient to scatter the projectiles. The arch itself did not collapse and was still apparently strong enough to bear the load for which it was designed, that is, 300 lb. per square foot.

The concrete was thoroughly mixed in the proportion of 1 bbl. of cement, 11 cu. ft. of sand and 19 cu. ft. of broken stone, and was carefully placed, but there was no steel reinforcement. The arch was built Feb. 25 and broken Aug. 15.

Yours very truly,

Charles W. Kutz,
Captain, Corps of Engineers.

West Point, Sept. 24.

Condenser Intake and Discharge Conduits.

Sir: What is the usual method of figuring the cross section of intake and discharge conduits for supplying condensing water to power station equipment, same to be based on the amount of water used and the distance traversed? Is there any standard work giving rules relating to this subject?

Pawtucket, R. I. Benjamin Gridley.

[In the absence of published information on the design of conduits for condenser circulation water supply, it may be stated that as conduits for this purpose are rarely more than a few hundred feet in length, the problem usually resolves itself into the use of good judgment in selecting ample sections for low velocities of flow and to provide for future extensions of plant rather than a study of the conditions that govern the flow of water in long conduits. Recent practice in this country indicates a general tendency to keep the velocity of flow in both intake and discharge conduits below 5 ft. per second, and where the water is taken from sources of varying water level, it is customary to depress the conduits, if possible, to such levels that the intake conduit is always full or partly full at the lowest water level. In many cases, the discharge tunnel will be found placed at a higher level than that for the intake, since, if it is desired to operate the pumps on the closed circulation system, this may always be accomplished by damming the conduit near its discharge outlet in order to maintain the water level at such height as to always cover the ends of the condenser discharge pipes. An important feature of the intake conduit is the provision of screens or trash racks, which precaution must be taken in practically all locations. These screening devices are, however, of widely varying design, but are all located in enlargements of the conduits in order to secure the necessary reduction of flow velocity, and in most cases there are two sets of racks provided so that one may be removed for cleaning, leaving the other still in service. The relative proportions of the intake and discharge conduits also vary considerably with differing conditions, many preferring a smaller section in the discharge conduit with consequent higher velocity of outflow. But in all cases, the preference has been shown by recent practice for intake conduit sections that will give flow velocities not to exceed 5 ft. per second, and as much larger sections as limits of cost will permit.]